CANADIAN ELECTRONICS ENGINEERING

MAY 1959
A Maclean-Hunter publication
five dollars a year

Nuclear reactor goes into operation at McMaster 11

Novel static inverter controls windshield heaters 20

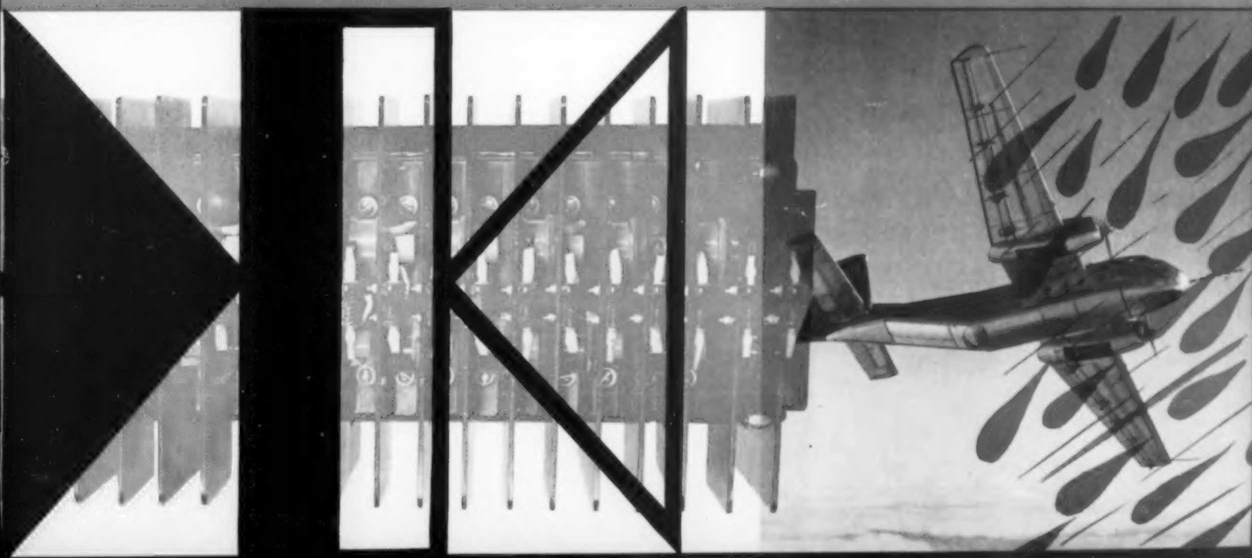
Canadian firms must find new markets 27

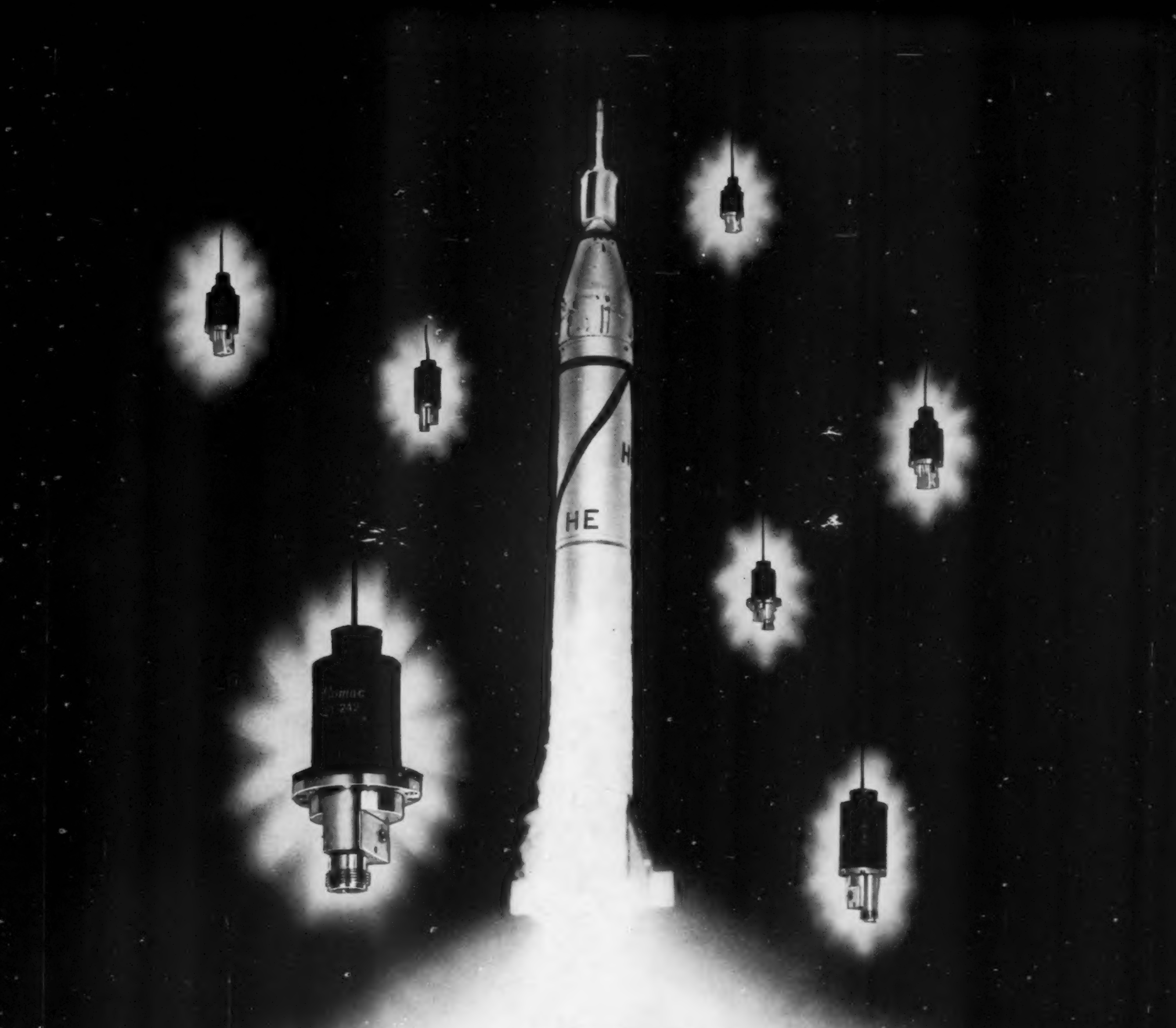
How compandors improve voice circuits 30

The transistor as a four-terminal network—Part 2 34

Miniaturized carrier system uses transistors 38

full contents 1





BOMAC BEACON MAGNETRONS

Pioneer space probe shown being launched by a Jupiter C missile. Bomac beacon magnetrons are an integral part of these programs.

MINIATURIZED · WITHSTAND HIGH SHOCK · LIGHTWEIGHT

For the highest possible reliability under the most severe environmental conditions, Bomac's complete line of beacon magnetrons have proved they can take it. They have successfully withstood accelerations of 20,000 g's, have survived centrifuge tests where the applied acceleration was in the order of 20,000 g's, and have operated satisfactorily when subjected to vibrations at a 30-g level from 50 to 2000 cps.

Tube	Ef Volts	If Amps	Peak Anode Voltage	Peak Anode Current Amps	Peak Power Watts	Frequency Mcs	Output Mates To	Weight	B
BL-212	5.0	0.5	1200 V	0.8	100	5400–5900	50 Ω SM Jack	8 oz.	
BL-223	5.0	0.7	1900 V	1.1	400	5400–5900	50 Ω TNC Plug	10 oz.	
BL-226	5.0	0.5	1300 V	0.9	100	9100–9500	50 Ω TNC Plug	8 oz.	
BL-227	5.0	0.5	1300 V	0.9	100	8700–9100	50 Ω TNC Plug	8 oz.	
BL-228	5.0	0.5	1300 V	0.9	100	8300–8700	50 Ω TNC Plug	8 oz.	
BL-230	5.0	0.7	2800 V	1.9	1000	5400–5900	50 Ω TNC Plug	10 oz.	
BL-231	5.0	0.5	1450 V	1.0	200	5400–5900	50 Ω SM Jack	8 oz.	
BL-233	5.0	0.7	2800 V	1.5	1000	9375	UG 40/U	11 oz.	
BL-242	5.0	0.7	1900 V	1.1	400	5400–5900	TNC or 50 Ω N Plug	10 oz.	
BL-243	5.0	0.5	1450 V	1.0	200	5400–5900	50 Ω SM Jack	8 oz.	
BL-245	5.0	0.7	2800 V	1.9	900	5400–5900	50 Ω TNC Plug	10 oz.	
BL-247	5.0	0.5	1200 V	0.8	100	9100–9500	50 Ω TNC Plug	8 oz.	
BL-250	5.0	0.5	1350 V	1.0	150	5400–5900	50 Ω TNC Plug	8 oz.	
BL-M003	5.0	0.5	1300 V	0.9	100	9100–9500	50 Ω TNC Plug	7 oz.	
BL-M004	5.0	0.5	1200 V	0.9	150	8900–9100	50 Ω TNC Plug	8 oz.	
BL-M007	5.0	0.5	1300 V	0.9	100	9100–9500	50 Ω TNC Plug	8 oz.	
BL-M008	5.0	0.7	2200 V	1.1	400	5400–5900	50 Ω TNC Plug	10 oz.	

Leaders in the design, development and manufacture of TR, ATR, Pre-TR tubes; shutters; reference cavities; crystal protectors; silicon diodes; magnetrons; klystrons; duplexers; pressurizing windows; noise source tubes; high frequency triode oscillators; surge protectors.

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Salem Road, Beverly, Massachusetts

May 1959

Volume three, number 5

CANADIAN ELECTRONICS ENGINEERING

Astronautics — will we miss the boat?	*Editorial*	19
***Novel static inverter controls electric windshields in "Caribou"**	*Design: aeronautical and navigational electronics*	20
Canadian firms must find new markets	*Convention reports*	27
How compandors improve voice circuits	*Application: communications systems*	30
The transistor as a 4-terminal network — Part 2	*Design: circuit theory*	34
Miniaturized carrier system uses transistors	*Design: communications systems*	38

Departments

Contributors	3
News highlights	5
People in the industry	7
Reports from the industry	11
For your library	42
New products	44
Defence contracts	48
Round up: coming events	54

***our cover design** *Art director Frank Davies has skillfully combined all the essential elements of the static inverter that controls the electric windshields of the "Caribou."*

CANADIAN ELECTRONICS ENGINEERING

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Authorized as second class mail, Post Office Department, Ottawa.

Printed and published by Maclean-Hunter Publishing Company Limited, 481 University Avenue, Toronto 2, Canada. Address all correspondence: P.O. Box 100, Toronto, Canada.

Horace T. Hunter, Chairman of the Board; Floyd S. Chalmers, President; Donald F. Hunter, Vice-President and Managing Director.

Publishers of Business newspapers in Canada: Building Supply Dealer, Bus and Truck Transport, Canadian Advertising, Canadian Automotive Trade, Canadian Aviation, Canadian Baker, Canadian Electronics Engineering, Canadian Grocer, Canadian Hotel Review, Canadian Industrial Photography, Canadian Jeweller, Canadian Machinery, Canadian Missiles and Rockets, Canadian Packaging, Canadian Paint and Varnish, Canadian Printer and Publisher, Canadian Shipping, Canadian Stationer, Civic Administration, Design Engineering, Drug Merchandising, Electrical Contractor, L'Epicier, The Financial Post, Food in Canada, Fountains in Canada, Hardware and Metal, Heating and Plumbing Engineer, Home Goods Retailing, Marketing, Materials Handling in Canada, Men's Wear, Modern Power, Modern Purchasing, National Builder, Office Equipment and Methods, Painting and Decorating, Le Pharmacien, Photo Trade, Plant Administration, Progressive Plastics, Le Quincaillier, Style. Business newspapers in U. S. and U. K.: The Inland & American Printer & Lithographer, Rock Products, Concrete Products, British Printer, British Rate & Data.

Other services: The Financial Post Corporation Service; Canadian Press Clipping Service; Commercial Printing Division.

Offices at 1242 Peel Street, Montreal; Room 1004, The Burrard Bldg., 1030 West Georgia Street, Vancouver 5, B.C.; Bremen, Germany, Auf den Haefen 12; Maclean-Hunter Limited, 125 Strand, London, England.

Subscription rates: Canada $5.00 per year, two years $9.00, three years $13.00. Single copy price $1.00. U. S. A., United Kingdom, $10.00 per year; all other countries, $20.00 per year.

Indexed in Engineering Index.

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contributors and special articles in this issue:

With all the publicity of recent months about the CF-105, many of us have overlooked the fact that the Canadian aircraft industry has been producing some very successful aircraft. One of them is the de Havilland Caribou.

A. E. Maine (Novel static inverter controls electric windshields in "Caribou") has prepared a fine description of some of the electronic equipment designed for the aircraft. Mr. Maine has had industrial control equipment experience with Marconi Instruments in England. During World War II he lectured in the British Army, then did development work at the newly formed RAE Guided Projectiles Establishment.

After the war he joined the de Havilland Propeller Co. as an electronics engineer and later became head of the electrical design group. Later he entered the company's guided missile division.

Since 1955 he has been with the de Havilland Aircraft of Canada, guided missile division. In 1958 he was appointed chief electronic engineer of that division.

Mr. Maine has specialized in high-power static inverter engineering in recent months. His private interests have been concentrated in the field of astronautics; currently, he is secretary of the Canadian Astronautical Society.

Stanley E. A. Pinnell (How compandors improve voice circuits) was born in Winnipeg and received most of his education there. In 1945 he received his BSc degree in mathematics and physics from the University of Manitoba. Then he went on to get his MSc degree from the University of Alberta. Later, Mr. Pinnell did more postgraduate studying at the University of Minnesota and the Massachusetts Insitute of Technology.

In 1949 Mr. Pinnell joined RCA Victor Co. Ltd. as a research engineer engaged on classified projects. He left in 1955 to join Pylon Electronic Development Co. Ltd. as president.

Mr. Pinnell has had a number of technical papers published and has participated in several inventions. He is a member of the Short Wave Experimenters' Club and the IRE.

Part 2 of the story by **Malcolm A. Gullen** (The transistor as a 4-terminal network) completes the paper.

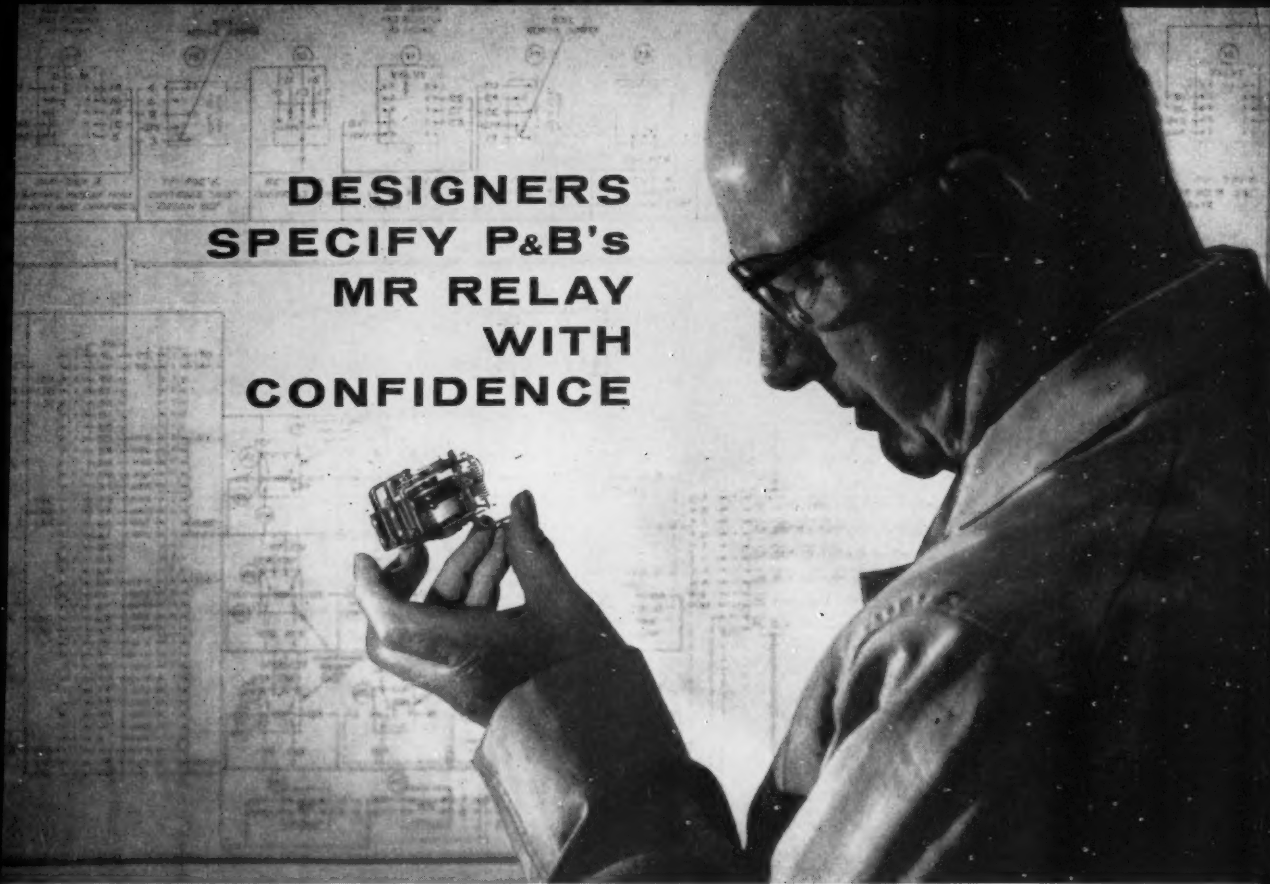
During the past month there have been a number of important conferences and expositions. The editors of CEE have attended some of them to try to find any significant trends in the industry. Their findings appear in the report starting on page 27 (Canadian firms must find new markets).

DE HAVILLAND

Maine

MARKOW

Pinnell



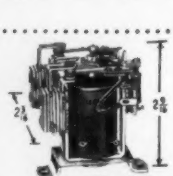
for a host of control applications

RELIABILITY coupled with low cost are two factors which place the MR series relays high on P&B's best seller list. They are being used in a multiplicity of designs . . . transmitters, street lighting equipment and small motor starters, to name but a few.

Both AC and DC models are available, with AC coils ranging up to 440 volts. All are adaptable for printed circuit mounting. The wide variety of contact arrangements include:

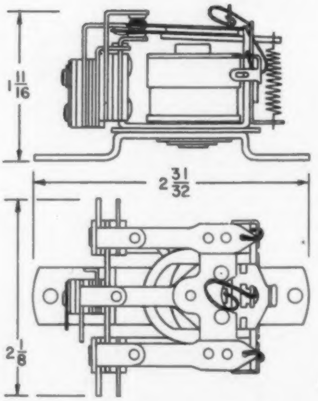
SPST-NO	SPST-NC-DB	DPST-NC	3PST-NC
SPST-NC	SPDT	DPDT	3PDT
SPST-NO-DB	DPST-NO	3PST-NO	

For more information about this medium duty, compact relay, call or write today—or get in touch with the P&B sales engineer nearest you. See our complete catalog in Sweet's Product Design File.



LM SERIES: Plate circuit relays similar to the MR. All sp and dp contact arrangements shown above are available. Coils are wound to specified resistances up to 58,000 ohms max. Sensitivity ranges from 15 mw min. (single pole) to 70 mw min. (double pole).

MR SERIES



Temperature Range:
DC —55°C. to +85°C.
AC —55°C. to +75°C.

Pull-in: Approx. 75% of nominal dc voltage; 78% of nominal ac voltage.

Weight: 4 ozs.

Dimensions: $2\frac{31}{32}$" long x $2\frac{3}{16}$" wide x 2" high.

Mounting: Two $\frac{5}{32}$" dia. holes. Can be adapted for printed circuits.

CONTACTS:

Arrangements: Up to 3pdt.

Material: $\frac{7}{32}$" dia. silver. (Others available).

Load: 8 amps @ 115 volts, 60 cycle, resistive.

COIL:

Max. Resistance: 34,500 ohms.

Power: 1.5 watts dc; 3.25 volt-amps ac. Will withstand up to 6 watts at 25°C.

Voltages: Up to 110 volts dc; up to 440 volts 60 cycle ac.

GENERAL SPECIFICATIONS:

Breakdown: 1500 volts, 60 cycle rms between all elements.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD CANADA LTD.

GUELPH, ONTARIO

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News highlights . . .

Bogue Electric gets Sage subcontract . . .

Burroughs Corp., Detroit, has subcontracted more than $300,000 in power equipment for its Sage data processing units to Bogue Electric of Canada Ltd., Ottawa. Cabinets to house the Bogue units will be shipped to Ottawa, components installed and shipped back to Burroughs' military electronic computer division at Detroit. Subcontract is in line with the U.S.-Canadian policy of joint defense participation.

New Canadian radio hits U. S. market . . .

RCA Victor has been awarded a $1 million U.S. contract for Canadian-designed radio transmitters and receivers. The sets, known as Mark 4, single side band transmitter-receivers, can handle approximately twice as many messages because of a halving of the bandwidth needed to transmit and receive. RCA's U.S. parent company will receive the first 1,000 and handle world-wide sales. One batch was ordered by India.

U. S. will honor some duty exemptions . . .

A waiving of either the Buy American Act or U.S. duties on certain joint defense and other items that cross the border from Canada is getting the Pentagon's stamp of approval. Political problems prevented blanket exemptions for defense items built in Canada for U.S. firms, but Canadian defense production and procurement officials expect a boost in subcontracts and a modest increase in prime contracts. There is also a chance that Canada will get some research contracts from Washington.

Radio licence renewals not automatic . . .

The Board of Broadcast Governors announced it was against automatic renewal of broadcasting licenses on the grounds that radio stations should have their performance reviewed because of the board's responsibilities under the Broadcasting Act. With 171 licenses coming up for renewal, the board recommended dividing stations into groups and staggering their renewal schedules. It also suggested a change in the Radio Act to allow a shortening of the normal five-year renewal period.

Robotron firm will build in Ontario . . .

The Robotron Corp. of Detroit expects to build a 5,000 square foot Canadian plant in the Sandwich West industrial park, Windsor. New plant will manufacture electronic controls for resistance welding, automated machine tools, precision test equipment and safety, and will serve the automotive and other durable goods industries.

Pay-as-you-see tv makes Canada debut . . .

The first pay-as-you-see television-movie operation is making its Canadian debut in Kimberley, B.C. Called Selectivision, the operation is non-licensed, advertising-free, pre-censored, and carries first-run movies by coaxial cable over a closed circuit. Picture is picked up on sets for which owners have bought decoders.

Sperry system bids for U. S. industry . . .

Sperry Gyroscope Co. of Canada is aiming for a $10 million annual share of the U.S. machine-tool market with its Canadian-designed and built automatic machine-tool control system for positioning work or tools by taped commands. Already, Sperry has sold 15 systems, priced up to $17,000 a unit, all but one to American concerns.

People in the industry

Director of engineering appointed at General Instrument

General Instrument — F. W. Sickles of Canada Ltd., Waterloo, Ontario, has appointed **Ernest A. Thomas** as director of engineering, covering all Canadian operations of the company. This new position has been created as a result of expanding operations and the introduction of new product lines including meteorological devices and semiconductors. Prior to this appointment, Mr. Thomas was chief engineer for the radio and television division of Canadian Westinghouse Co. Ltd.

Vice-president and general manager

An Erie Resistor employee for the past 25 years, **George F. Kempf** has been promoted to vice-president and general manager of Erie Resistor of Canada Ltd. Prior to this he held the position of general manager.

Hired in 1933 as a resistor molding machine operator, Mr. Kempf served in various capacities in the Erie plant until 1942 when he was promoted to research technician in the engineering department. In 1943 he was promoted to research engineer, in 1952 to manager of production engineering, and in 1953 to chief production engineer.

Honeywell engineer moves to Europe

Former Canadian sales manager for the industrial division of Honeywell Controls Ltd., **R. J. (Rod) Bilodeau** has assumed the newly created position of general manager, industrial equipment division, continental Europe, for the Honeywell organization. From his headquarters in Frankfurt, Germany, Mr. Bilodeau will direct and co-ordinate the activities of Honeywell's various subsidiaries and distributors in Europe.

Born in Levis, Quebec, Mr. Bilodeau attended St. Patrick's high school in Quebec City. After three years' service with the RCAF he attended St. Francis Xavier University, Antigonish, N.S., and McGill University, Montreal. He graduated from McGill in 1948 with a degree in mechanical engineering.

CLM assistant general manager

Canadian Line Materials Ltd., has appointed **Les Jackson** as assistant general manager. Prior to joining CLM, Mr. Jackson was eastern district sales manager for Federal Pacific Electric. He is a professional engineer.

Comptroller for CAE

J. F. Tooley, president of Canadian Aviation Electronics Ltd., has announced the appointment of **George G. James, CA,** as comptroller of their western division in Winnipeg. Mr. James was born in England, but moved to Canada to receive his education in Winnipeg.

Engineer joins the Dominion Observatory

Angus C. Hamilton, P.Eng., has recently transferred from the Geodetic Survey of Canada to the Gravity Division of the Dominion Observatory in Ottawa. Mr. Hamilton graduated from the University of Toronto, Engineering Physics, 1949.

Canada Wire promotes two salesmen

After several years' experience with the inside sales staff of Canada Wire and Cable Co. Ltd., **G. R. Minor** and **J. R. Cumming** have been appointed sales representatives in the Toronto area.

New comptroller at CESCO

Canadian Electrical Supply Co. Ltd. has appointed **Jesse Cohen** as comptroller. Mr. Cohen served with the Royal Canadian Corps of Signals during World War II, then transferred to the Royal Canadian Naval Reserve after the war. He holds BA and B Comm degrees from Sir George Williams College where he studied accounting. Further studies were undertaken in economics at the McGill Graduate School.

Cohen

NOTT

Flewwelling

Manager for silicones

The appointment of **R. C. Flewwelling** as silicones manager for Bakelite Company, division of Union Carbide Canada Limited, was announced by W. S. Berry, sales manager.

A graduate in science and chemistry from Mount Allison University, Sackville, New Brunswick, Mr. Flewwelling joined the Union Carbide organization in 1955. Prior to this latest assignment he served as technical sales representative for Bakelite Company in Montreal.

Sola sales engineer

Sales engineer for Sola Electric (Canada) Ltd. in the Montreal area is **Guy V. Fortier.** Mr. Fortier is a graduate electrical engineer with several years' experience in the electronics field.

Thomas

Kempf

Bilodeau

Jackson

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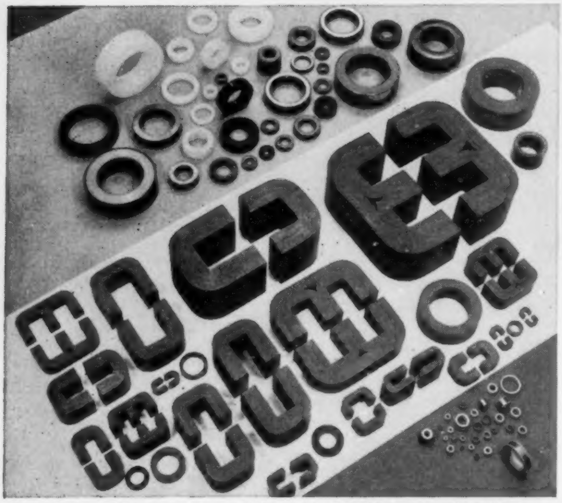
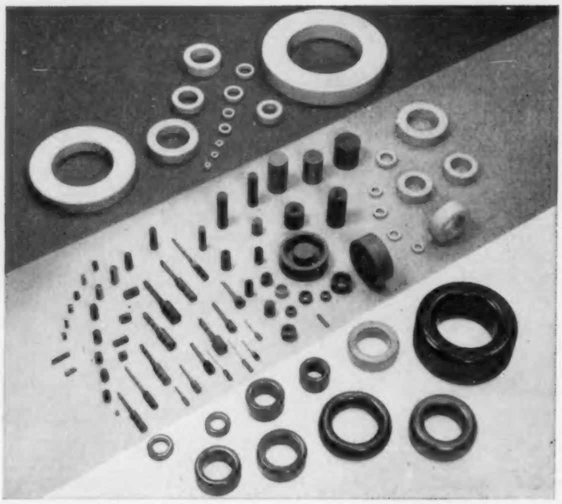
for your MAGNETIC CORE requirements



Top to bottom: Tape wound cores, Silectron C, E and O cores, and bobbin cores.



Top to bottom: Mo-Permalloy powder cores, iron powder cores, and Sendust cores.

SILECTRON C-CORES, E-CORES and TOROIDS Arnold C and E cores are made from precision-rolled Silectron strip in 1, 2, 4 and 12 mil thicknesses.

They are supplied in a wide variety of shapes, and in sizes from a fraction of an ounce to several hundred pounds. In addition to standard transformer applications, they may also be supplied for special applications such as saturable reactors, instrument transformers and pulse transformers.

Over 1,000 stock cores are listed in the Arnold Silectron catalog. A wide selection of preferred sizes are carried in stock for immediate shipment. For complete data on C and E cores and Silectron toroids, *write for Bulletin SC-107A.*

TAPE WOUND CORES of High Permeability Materials Arnold tape wound cores are available made of Deltamax, 4-79 Mo-Permalloy, Supermalloy, Mumetal, 4750 Electrical Metal, Silectron, or the new rectangular-loop material, Supermendur. All except Supermendur cores are available in standard tape thicknesses of ½, 1, 2, 4 or 12-mils.

Toroidal cores are made in 30 standard sizes with protective nylon or aluminum cases. Special sizes of toroidal cores are produced to individual requirements. *Write for Bulletin TC-101A. (TC-113A for Supermendur Cores.)*

BOBBIN CORES Arnold bobbin cores are available in a wide range of sizes, tape thicknesses, widths and number of wraps to suit the ultimate use of the core in electronic computer assemblies. Magnetic materials usually employed are Deltamax and Square Permalloy in standard thicknesses of 1, ½, ¼ and ⅛ mil. Bobbins are supplied in ceramic or stainless steel. *Write for Bulletin TC-108A.*

MO-PERMALLOY POWDER CORES Available in a wide range of sizes, from .260″ OD to 5.218″ OD. They are given various types of enamel and varnish finishes, some of which permit winding with heavy Formex insulated wire without supplementary insulation over the core.

These powder cores are supplied in four standard permeabilities: 125, 60, 26 and 14 Mu. They provide constant permeability over a wide range of flux density, and in many cases may be furnished stabilized to provide essentially constant permeability over a specific temperature range. Large warehouse stocks of preferred sizes are carried for immediate shipment. *Write for Bulletin PC-104B.*

IRON POWDER CORES A wide selection of cores is available, from simple cylinders to special cores of complicated design. The line includes all standard types of threaded cores, cup, sleeve, slug and cylindrical insert cores: for use in antenna and RF coils, oscillator coils, IF coils, perm tuning, FM coils, television coils, noise filter coils, induction heating and bombarder coils, and other low frequency applications. Preferred sizes are carried in warehouse stock for quick shipment. A standard series of iron powder toroids is also manufactured, conforming to the standard sizes proposed by the Metal Powder Industries. *Write for Bulletin PC-109.*

SENDUST POWDER CORES Available in a wide selection of sizes, ranging from .800″ OD to 3.346″ OD, and in permeabilities of 10, 13, 25, 30, 50 and 80, although not all sizes are available in all permeabilities. They possess magnetic properties generally superior to iron powder cores, but inferior to Mo-Permalloy powder cores in the audio and carrier frequency range. *Write for Bulletin SDC-110.*

SPECIAL MATERIALS

2V PERMENDUR . . . a ferromagnetic alloy of cobalt, vanadium and iron that possesses high flux density saturation properties. Its magnetostrictive properties are useful in many transducer applications. *Write for Bulletin EM-23.*

VIBRALLOY . . . a ferromagnetic alloy of nickel, molybdenum and iron whose temperature coefficient of elastic modulus is controllable over a wide range. It has high ferromagnetic permeability, and a rather high coefficient of magnetostriction. Used in applications where a zero or controlled thermo-elastic coefficient is desired.

BARIUM TITANATE . . . A piezoelectric ceramic widely used in accelerometers, phono pickups, microphones, ultrasonic grinding and cleaning devices and underwater signaling devices. For more information, *write for Bulletin CM-116.*

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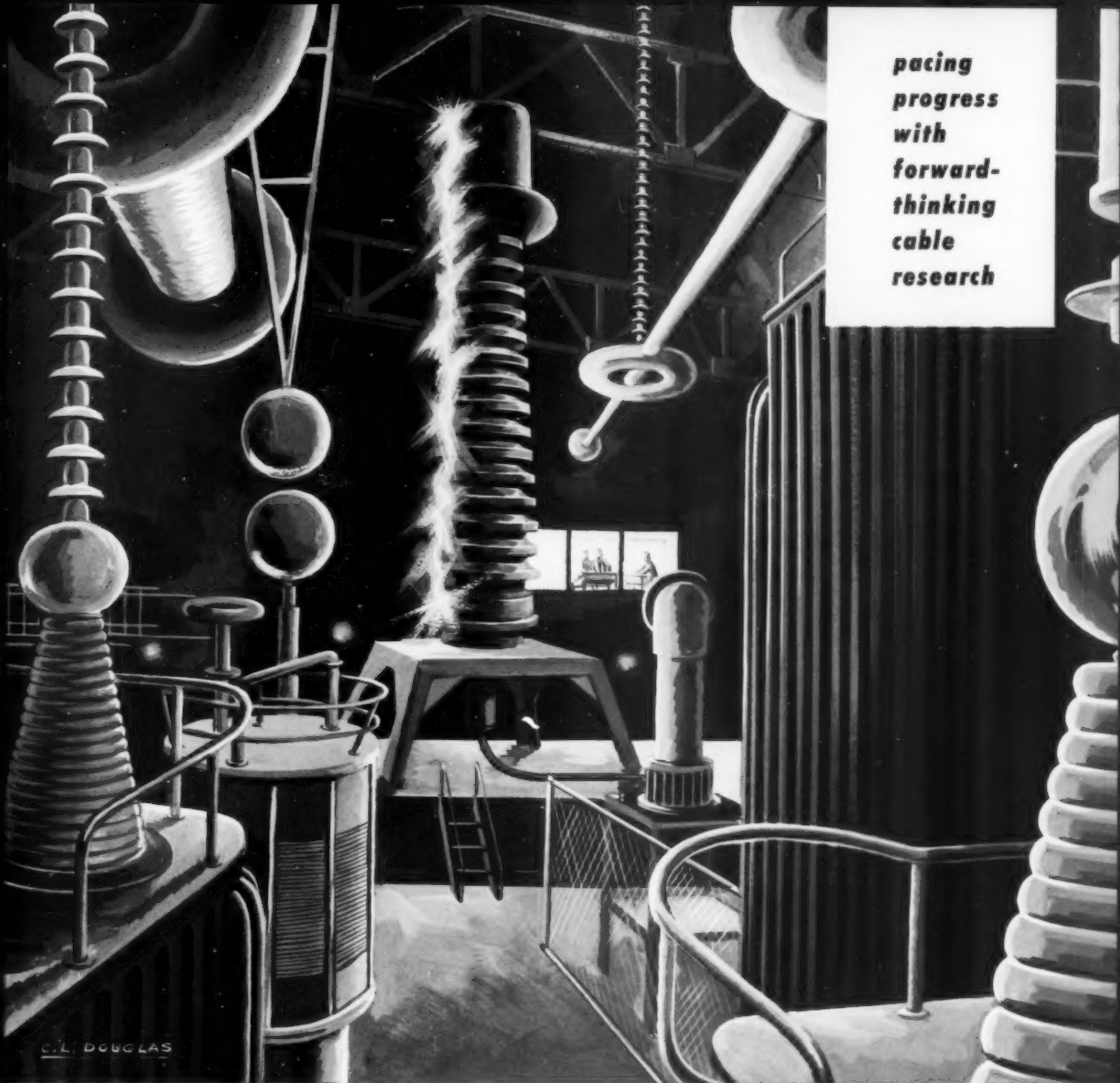


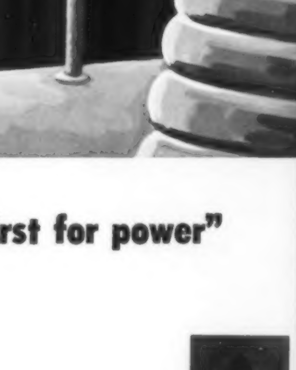
PROBLEM: Increase load capacity to slake the "thirst for power"

By 1960, power consumption in Canada will skyrocket to 114.5 billion kwh . . . and keep on growing.

Increasingly more power is demanded everywhere. To transmit and distribute it economically demands power cables capable of carrying more amperes per dollar of installed cost.

Here at Canada Wire's Research and Development Laboratories . . . the most complete in Canada . . . researchers with the certain, particular knowledge of requirements peculiarly Canadian, are well ahead of the problem. Dramatic progress has been made with power cables that pay big dividends in load-carrying capacities with no increase—often reductions—in conductor size. Abnormally high voltage tests confirm cable and accessories performance, far beyond industry specifications, in every important physical and electrical property.

Forward-thinking cable research is part of the technical competence that keeps Canada Wire ready with solutions to problems as they arise. This competence is the "no-cost" plus you get with all "Red Reel" products.

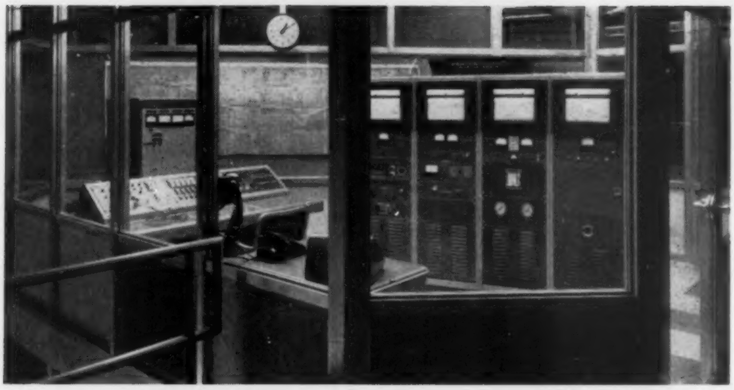


TRADE MARK REG'D.

QUALITY CABLE IS LOW-COST CABLE!

Canada Wire and Cable Company Limited

A Canadian Company Manufacturing and Selling Coast to Coast



All aspects of the McMaster nuclear reactor are controlled and recorded at this central control room. Reactor will be used primarily for research.

Swimming pool reactor goes into operation at McMaster

Fundamental research into the peaceful uses of atomic energy is the primary objective of the nuclear reactor that has just gone into operation at McMaster University, Hamilton, Ontario. Scientists at McMaster have pioneered in the application of radioisotopes to medicine, and the new reactor will provide them with facilities to extend the scope of their studies.

The reactor, rated at 1,000 kw thermal, is of the swimming pool type. This design was chosen for its inherent safety and its adaptability to experimental work. Costing $2,000,000, it was financed by grants from Government of Canada research agencies, the Hydro Electric Power Commission of Ontario and private industry.

The reactor will be supervised by Dr. H. G. Thode, director of research. Assisting him will be a nine-man operational control committee under the chairmanship of D. M. Hedden, assistant director of research.

Dominion Sound opens new Calgary branch

Dominion Sound Equipments Ltd. has opened a new district sales office and warehouse in Calgary at 731-10th Avenue Southwest. District Manager W. F. Graham said the move to larger premises was needed to keep pace with the company's rapid growth of business in this area.

New communications lab for classified research

The National Research Council is building a new communications laboratory at Rideau Heights, Ottawa, to handle classified research and development in specialized communcations for government departments.

Designed to accommodate 500 people, the new building will house the communications branch now located in rented quarters in Ottawa's Rideau Annex building. Aim of the research is to provide secure communications for the defense and other government departments. Estimated construction time is two years.

Canadian firms acquire new principals

Ultrasonic Engineering Co., Maywood, Illinois, has appointed **Electrolabs,** 7385 St. Lawrence Blvd., Montreal, as its exclusive Canadian representative. The Illinois firm makes a line of sonic and ultrasonic equipment for industrial, medical and scientific use.

Tele-Radio Systems Ltd., of Toronto, has been appointed Canadian representative for Airtronics International Corp., Fort Lauderdale, Florida. Airtronics introduced a new program equalizer for use on broadcast wire line circuits.

Ferrotran Electronics Co. has appointed **William H. Hummel,** Port Credit, Ontario, as manufacturer's representative for Ontario to handle the sale of its transistor equipment and components.

Anthony Foster and Sons Ltd., of Toronto, Montreal, Winnipeg and Vancouver has been named Canadian distributor for aircraft wire and cable manufactured by the general products group of the Electric Auto-Lite Co.

Dayrand Ltd., Montreal, is now the exclusive Canadian representative for Carl W. Schutter Microwave Corp. of Long Island, N.Y., producer of waveguide and waveguide fittings.

Micro-Test Inc., California, has appointed **A. C. Wickman Ltd.** as its sole Canadian representative for its line of weldable strain gauges used for application to clean surfaces by spot-welding. Another new principal for A. C. Wickman is Telco, of Paris, France, manufacturer of intracardiac micromanometers, manometers, pressure sensitive heads, amplifiers, as well as complete systems for surgical procedures and catheter investigations.

New location for firm

Effective May 1, 1959, the head office of E. E. Whittaker, electronic manufacturers' representatives, will move from Arnprior to 2137 Niagara Drive, Ottawa.

Company changes name and ownership

W. Gary Wright Electronics of Canada Ltd. has changed to Canadian ownership under the new name of Croven Ltd. The address remains at 628 Kent St., Whitby, Ontario.

J. R. Wolter, president of Croven Ltd., has announced the appointment of Paul A. MacPhee as vice-president, sales. His duties include the direction of sales, sales promotion and advertising for the company's quartz crystals and crystal ovens.

Western sales company

G. D. McRae and J. S. Baxter have left Canadian Marconi Co. to form their own company, Pacific Electronics Ltd., 1641 West Second St., Vancouver, B.C. They will handle a complete line of tubes, components and equipment for service technicians and industrial accounts in B. C.

VINCENT

McRae

CROTON

Baxter

Mr. McRae has been general sales manager of the Electronic Tube and Components Div. of Canadian Marconi Co. in Toronto for the past five years. Mr. Baxter has been branch manager in Vancouver for the past seven years.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Output Level & Impedance: 5 dbm maximum, into 600 ohms, unbalanced. May be paralleled with any number of other Keyers operating on different frequencies in the same audio system.
Power Requirements: 14 V DC, 15 MA. Two transistorized power supplies and one automatic change-over relay are mounted on the rear of each mounting shelf.
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Power Requirements: 14 V DC at 30 MA. Two transistorized power supplies and one automatic change-over relay are mounted on the rear of each mounting shelf.
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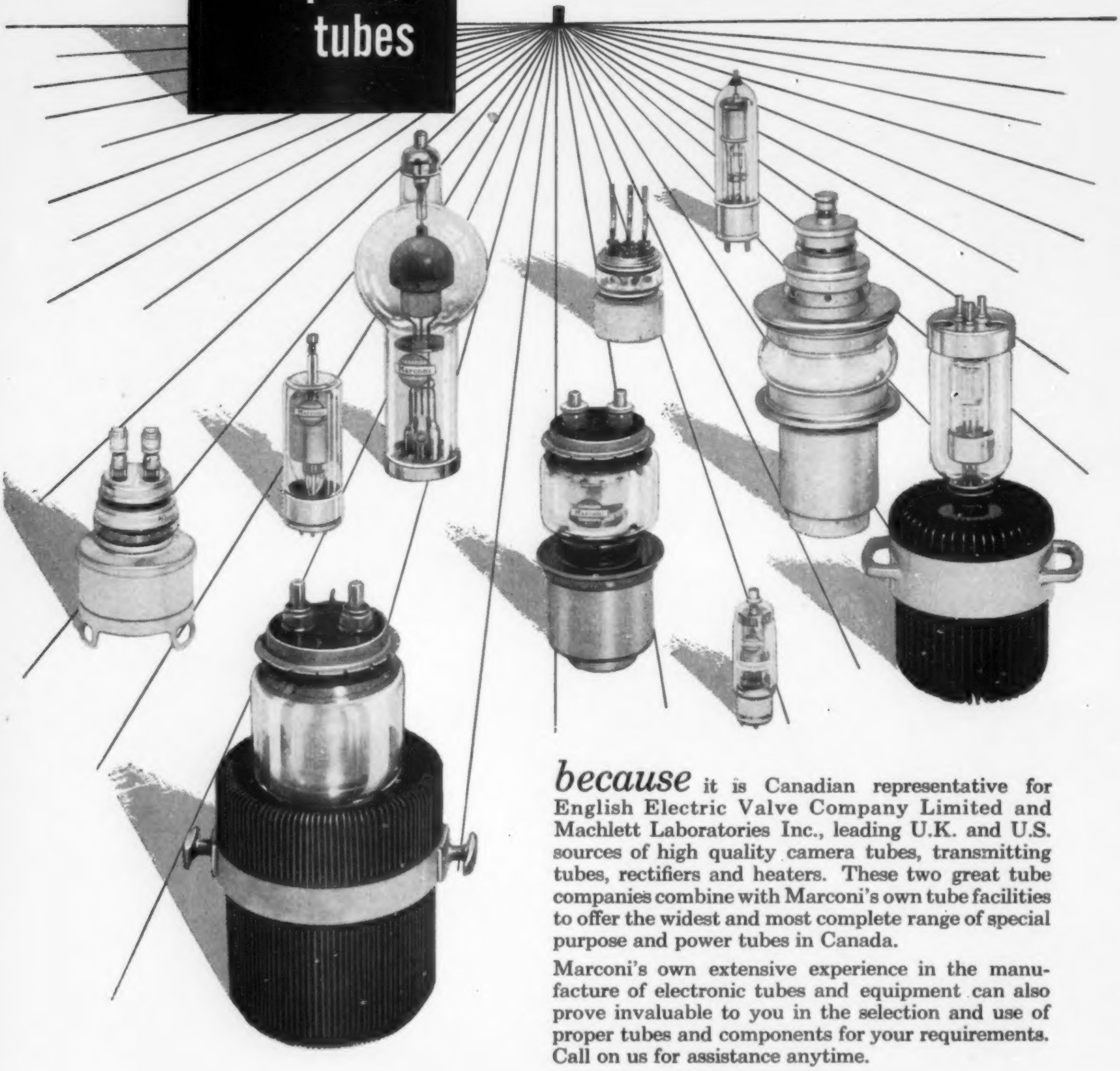

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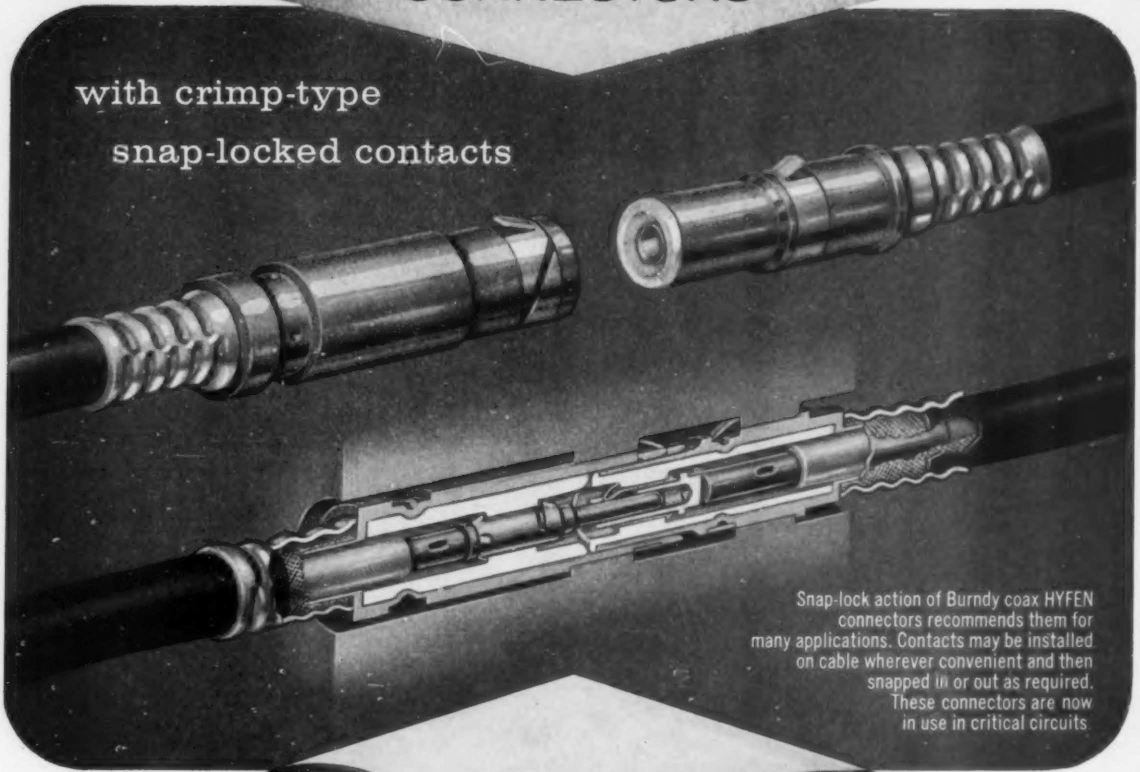

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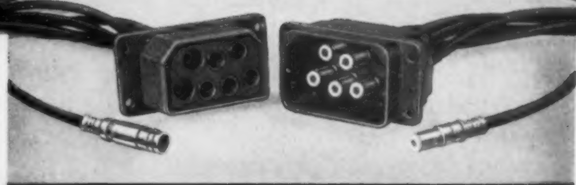

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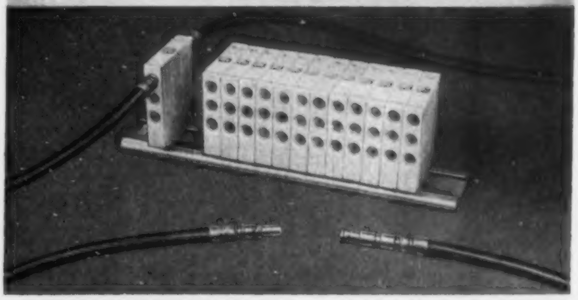

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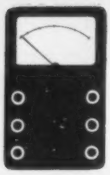

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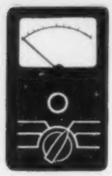

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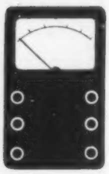

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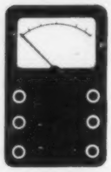

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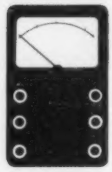

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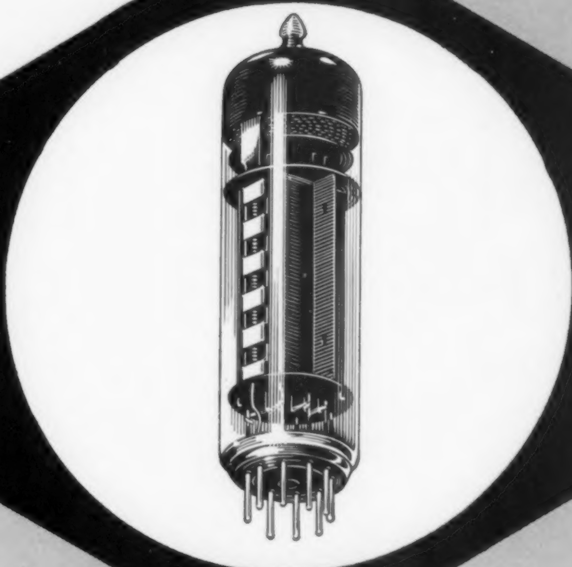

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Astronautics—will we miss the boat?

An important conference will be held in London, England, this year and unless fast action is taken by the government, Canada will be made highly conspicuous by the absence of an official delegation. We refer to the symposium that will further explore the technical and economic aspects of a Commonwealth space research program, a possibility suggested by the Commonwealth Astronautic Committee at its first meetings last year.

On January 12, 1959, the Canadian Astronautical Society sent to the office of the Prime Minister a brief urging the Canadian Government to examine the question of Canada taking part in such a program. They also asked the government to underwrite the attendance of four top Canadian scientists at this important meeting.

In his letter of acknowledgement, Mr. Diefenbaker stated that the representations made had been carefully noted and the matter referred to the Minister of National Defence for further consideration. Mr. Pearkes, however, replied that the Government was not in a position to pay the expenses of a delegation. A further communication from the Society, giving additional detail and background information to support their original brief, has only served to elicit a further assurance that the Society's views will receive careful attention.

But time is short, and a delegation will have to be chosen in the very near future if it is to go to London fully prepared. We can understand there being some hesitation in committing Canada to an active part in any proposed space research undertaking before it has received detailed consideration. What we find hard to believe is that the relatively small sum of $6,000 to $7,000 cannot be found for the first step in examining the proposal.

Some of the possible advantages of a joint Commonwealth research endeavor were pointed out in the CAS brief: Canadian participation in the program would be of great value toward sponsoring and maintaining in this country a nucleus of scientists and engineers proficient in the vital space research frontier, and at the same time permit this country to take its rightful place in the astronautical field. One important aspect is that participation, rather than complete management, would yield considerable scientific and other advantages, but with only a reasonable outlay. Also, the deeper bonds that would be developed among Commonwealth scientists would represent an important and beneficial force in this family of nations.

The editor of the CAS Proceedings summed up the situation very neatly — we shall let him have the last word: "It is barely possible that Canada cannot afford to attend this Commonwealth round-table, but it is certain that she cannot afford not to."

THE EDITOR

Novel static inverter controls electric windshields in "Caribou"

A. E. MAINE*

A static inverter rated at 1.32 kw, using magnetic amplifier and transistor circuitry, has been developed as an aircraft windshield heater supply. Particular attention has been paid to protection and safety circuits to ensure reliable operation and provide for "fail-safe" conditions

Of the various methods presently available for preventing ice build-up on aircraft windshields, the use of electrically heated laminated plastic panes promises to be superior to all others especially in regard to the preservation of excellent vision at all times together with a significant saving in system all-up weight.

The panes themselves take the form of two contoured, clear plastic laminates between which a transparent film of gold is sandwiched. This film, which forms the heating element, is graded so that a pre-determined power density is obtained across the window, emphasis being given to the more important direct viewing central area. The transparent bus bars feeding the heating zones lead to terminals at the edge of the pane, internal connection being made by a short metallic pig-tail. The window temperature is sensed by means of a nickel wire filament type thermometer element also sandwiched between the plastic panes, and operating temperature is manifested by proportional changes of its electrical resistance.

The control scheme involved in using this type of windshield is essentially simple and consists of an electrical power modulator feeding the windshield heater, the modulator in turn being controlled by the thermometer element in such a way that the element resistance, and hence temperature, is kept sensibly constant. This simple closed-loop control ensures that the proper amount of electrical power is applied at all times irrespective of the prevailing ambient conditions.

The type of power modulator employed is determined largely according to whether or not ac power is readily available in the aircraft. If it is, simple magnetic amplifiers, for example, form a convenient means of control. If, however, only dc power is available, the choice exists between providing suitable inverters or employing a relatively crude "on-off" type of control using relays. The latter method is not attractive because of severe relay wear and attendant unreliability. In the case of the Caribou aircraft, rotary inverters were not favored, chiefly on account of their considerable weight. Consequently thoughts were turned toward finding a lighter and more efficient power modulator working directly from the dc line. The remainder of this article describes a static power inverter which was developed to meet the requirements and which uses magnetic amplifiers and transistors in a somewhat unusual combination.

Basic system

Figure 1 shows a block diagram of the inverter system. It will be noted that magnetic amplifiers are used for the initial stages of amplification, the final power output of 1.32 kw being provided by means of transistors. A low power transistor square-wave oscillator is employed to supply ac excitation to the magnetic stages, and for furnishing certain bias requirements.

A brief system study showed that any form of linear power stage was not only unnecessary but involved a

*Chief Electronic Engineer, Guided Missile Division, The De Havilland Aircraft of Canada Ltd., Downsview, Ont.

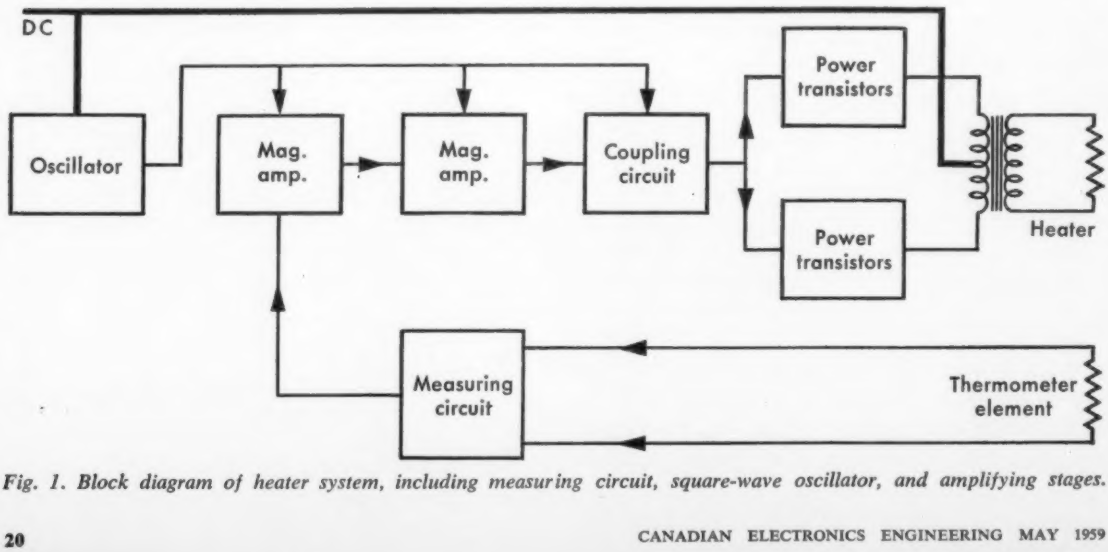
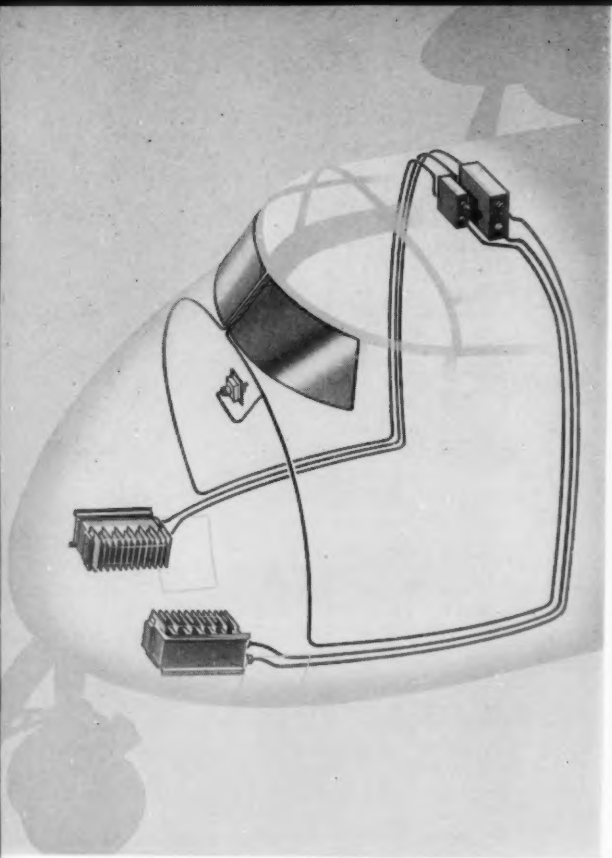


Fig. 1. Block diagram of heater system, including measuring circuit, square-wave oscillator, and amplifying stages.



Aircraft installation of windshield heaters and inverters

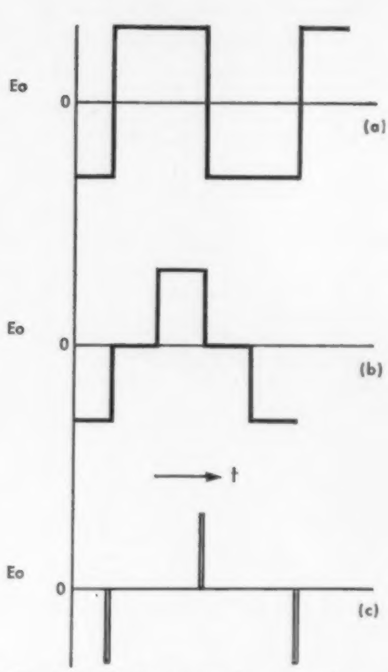


Fig. 2. Typical output voltage waveforms

prohibitive number of transistors, a poor efficiency and excessive weight. It was obvious that the transistors had to be used in their switching mode where, of course, maximum power handling capacity for a given collector dissipation may be achieved. Employing the switching mode, a crude "on-off" control could be provided, by means of switching the oscillator for example, but because precise temperature control of the windshield was required, a proportional power device was considered to be necessary. Meeting these dual requirements dictated the use of a form of pulse-width modulation, and the main development effort was directed toward achieving this with the minimum circuit outlay. The type of output voltage delivered by the inverter is shown in figure 2, the upper waveform representing full output, and the centre and lower waveforms indicating an intermediate and minimum output respectively.

Not shown in the block diagram are the several protective circuits, which are essential for safe and reliable operation of the inverter in the aircraft environment.

Low power oscillator

In order to operate the magnetic amplifiers and thereby produce the switching waveform for the power output stage, it is necessary to generate a clean square-wave within the control unit. Since the circuits producing the final drive voltage, and signal amplification operate at quite low power levels, only a relatively small oscillator is needed. A broadly defined optimum frequency exists for the oscillator: low frequencies result in an unnecessarily bulky output transformer, and high frequencies lead to poor wave-fronts due to the moderately low alpha-cut-off of the 2N174 transistors, which in turn increases collector dissipation. In the present application, a nominal frequency of 1400 cps was selected as being the best compromise.

The oscillator itself follows Royer's original magnetic multivibrator[1] quite closely, as shown in figure 3, there being only a small modification to the base drive circuits to guarantee prompt starting when the supply is turned on. The principle of operation is quite simple, the mechanics hinging upon the properties of the magnetic core which must possess almost, but not quite, complete remanence. In action, the core behaves as a time integrator of voltage; consequently a flux change from one saturation level to the other represents a fixed value of volt-seconds. During the normal flux change period, with the core unsaturated, the induced feedback voltages V_{lm} and V_{mn} are of such a polarity as to hold one transistor conducting and the other cut-off. Upon the flux level reaching one knee, the feedback voltages fall since the growing magnetizing current due to the onset of saturation cannot be supported. The fall continues until the voltages pass through zero and reverse sign, the latter arising out of a slight flux regression due to the incomplete magnetic remanence of the core. At this instant, the previously "on" and "off" transistors exchange their states, and the core flux is driven linearly with time toward the other saturation level, at which point the switching sequence described is repeated.

The small voltage developed across R7 applies positive bias to the transistors ensuring that conduction must take place in one or the other of the units; this changes the switching action slightly but the effect is not greatly significant. Having produced a symmetrical triangular flux in the core, as described, various magnitudes of square-wave voltage are simply derived by means of adding extra

Static inverter for "Caribou" windshields

windings to the oscillator transformer as required.

First stage magnetic amplifier

The circuit arrangement of the first stage magnetic amplifier may be easily distinguished in figure 3, and extends from the output terminals of the signal bridge to the control coil of the second stage. Of a conventional transformer-fed type (from oscillator windings P1-T1-P2), high gain is provided by the action of diodes CR1 and CR2 which provide self-saturation to the amplifier. This method of increasing gain is well known in the art and operates by suppressing an inherent negative feedback action present in the mode of operation of the elementary core structure. The non-reversible dc output from the amplifier, between points "X" and T1, is routed to the second stage control coil through a series resistance (R7) which has the effect of maintaining a short time-constant and suppressing certain second order effects which otherwse would disturb the action of the coupled amplifiers. Deltamax toroidal cores are used in the amplifier, which operates without bias and exhibits a transfer characteristic of the form shown in figure 4.

Second stage and coupling circuit

The operation of the second, or driving stage, is intimately tied up with the properties of the special coupling circuit, the arrangement of which, in turn, is dictated by the requirements of the base drive of the transistor power output stage. For these reasons it is desirable to shift considerations momentarily to the power stage.

Aside from ensuring that the second stage must be able to supply adequate drive so that the nine parallel groups of power transistors are switched completely on or off for the given load, it is equally important that the drive source impedance be kept very low and reverse biased in "off" periods if the catastrophic effects of thermal runaway are to be avoided. Thermal runaway is quite easily explained and is due to the effect of the collector cut-off current (I_{co}) flowing through the collector-base junction and around the base-emitter drive circuit. This leakage current behaves as a spurious signal appearing between base and emitter in a direction such as to turn

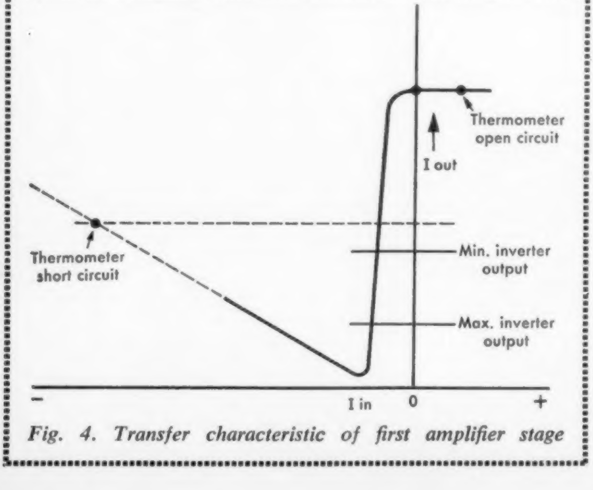


Fig. 4. Transfer characteristic of first amplifier stage

the transistor more "on." Since this current is supplied essentially from a current source (high collector resistance) it follows that the magnitude of the effect is determined in part by the value of the drive circuit resistance, which of course should be kept small. Now the value of I_{co} is determined by the transistor operating temperature and increases with it, and the temperature in turn is proportional to the square of the current. With an unduly high drive circuit resistance, a regenerative effect can be easily visualized in which all transistors would be fully turned "on" and followed almost immediately by their destruction through overheating.

Now turning to figure 3, diodes CR7 and CR8 convert the square waveform voltage from the oscillator secondary S5-S6-S7 to a direct voltage and this is used to pass a steady current through diodes CR5 and CR6 through their high-valued feed resistors R9 and R10. The effective resistance between each base group and the common positive emitter return bus line is consequently the dynamic resistance of the diodes CR5 and CR6; since these are silicon power types, the effective resistance is extremely low. Furthermore, the conduction voltage drop across each diode, about 0.8 vdc is sufficiently high to reverse bias all of the transistor base-emitter junctions to inhibit considerably further the flow of collector cut-off current. The coupling circuit therefore readily meets the requirement of preventing thermal runaway of the power stage transistors.

Considering the operation of the second stage magnetic amplifier, reference should be made to figure 5, which essentially is one half of the actual circuit, with the magnetic amplifier gate windings being replaced by a simple switch. This latter analogy is quite valid since over the course of any half-cycle of excitation the amplifier may be considered to be "off" when its cores are operating in the linear condition, and "on" when its cores are saturated.

The battery shown in the diagram represents the dc source provided by diodes CR7 and CR8 working in conjunction with the secondary winding S5-S6-S7 of the oscillator output transformer.

During the first part of the half-cycle of square wave excitation (of the polarity shown), it may be assumed that the magnetic amplifier is highly inductive, and therefore the switch "S" can be regarded as being open. In this period, current is supplied by the "battery" to the shunt diode CR5 thereby developing a reverse voltage e_r across the base-emitter junctions and at the same time presenting these junctions with a low dynamic resistance (approximately 0.1 ohms).

Later in the half-cycle, at a time determined by the magnetic amplifier control signal, saturation occurs and the switch "S" is effectively closed. Immediately this happens, the shunt diode is blocked and the current from the ac source divides at point "A," part circulating around the battery circuit and limited by R9, and the remainder applied as drive to the transistor power stage. In the following half-cycle, the circuit is inactivated by the diode CR3 and the mirror-image circuit (not shown in figure 5) assumes control of the power stage. The action of the magnetic amplifier-controlled diode coupling circuit is evidently to supply constant amplitude pulse-width-modulated drive signals to the main transistor power stage.

Power stage

The power stage consists of an output transformer and

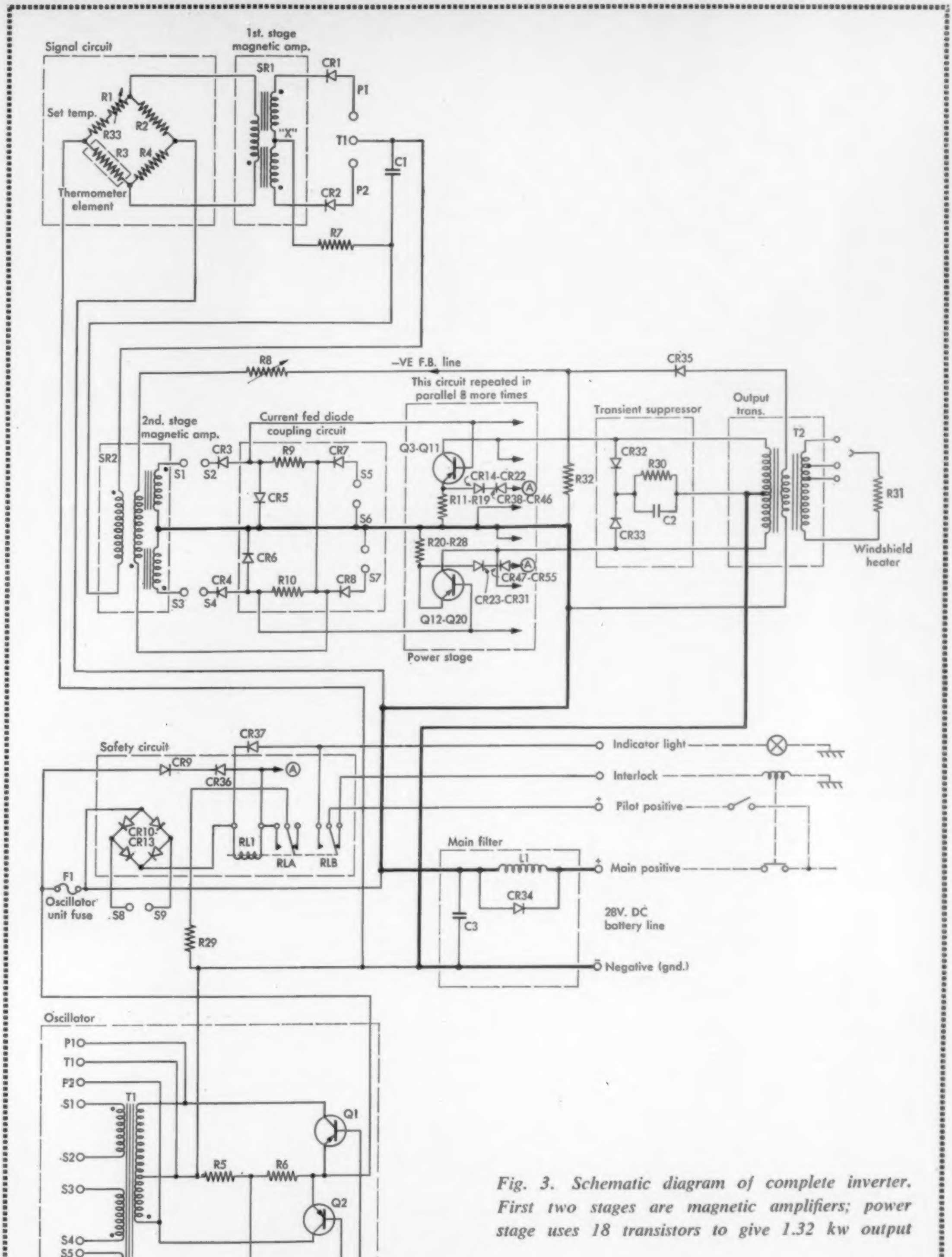


Fig. 3. Schematic diagram of complete inverter. First two stages are magnetic amplifiers; power stage uses 18 transistors to give 1.32 kw output

18 type 2N1100 germanium transistors employing the grounded-emitter connection and operated in parallel push-pull. Drive conditions approximate to Class B. A resistance of ¼ ohm is joined in series with each emitter, primarily for the purpose of ensuring proper load sharing in the parallel transistor groups. Each transistor together with its emitter resistor is mounted on a substantial aluminum fin, which ensures conservative collector ratings at peak currents up to 10 a per transistor. The dynamic load line (applicable to one transistor) is given in figure 6, the "area" or loop being the result of leakage reactance present in the output transformer. This reactive component, however, is of little consequence to the action of the stage.

The output transformer is constructed using 4-mil "C" cores, the primary winding taking the form of 14 turns of 0.8 in. x 0.022 in. copper strip, centre-tapped. The double-tapped secondary allows for matching the inverter to windshields graded into three batches according to their resistance range; it is uneconomical to attempt windshield manufacture to very close electrical tolerances.

A separate winding on the output transformer feeds a half-wave rectifier and load (CR35-R32), the dc voltage from which is passed to the common feedback and bias winding on the second stage magnetic amplifier. The connection of this negative feedback circuit lowers the output resistance of the inverter (optimum load 1 ohm collector-to-collector) and stabilizes the system gain.

PROTECTION AND SAFETY CIRCUITS

A vitally important aspect of static inverter engineering, not always given sufficient attention, is the provisioning of protective and safety circuits which ensure that the equipment has the best chance of operating reliably, and in the event of it failing, it does so safely.

Transient pulse suppression

One of the principal causes of transistor failure is due to transient voltage spikes appearing on the dc input lines arising largely out of inductive switching elsewhere in the dc system. In small inverters, a series transistor may be used and arranged to turn off when such transients appear. For larger units, such as the one described, where the steady input current can reach 65 a, this technique can no longer be applied. A somewhat less positive protection can be achieved by arranging for the oscillator to be turned off when transients appear. Both of these schemes involve additional active elements (transistors) which in themselves have reliability problems. The alternative approach is to use passive protective elements which tend to have a much better reliability but downgrade circuit design from sophistication to "brute force." In this inverter system, the latter course has ben adopted, and few tears shed for the elegant circuits consequently omitted.

The first attack on unwanted pulses is made in the main filter where the impedance of the aircraft wiring, together with an 80uh choke forms the series arm of a low pass filter, having a 3000uf capacitor bank for the shunt arm. The ac resistance of the tantalum capacitors used is surprisingly small and the filter gives appreciable attenuation of the frequencies involved in typical inductively generated transients. The shunt capacitor plays an almost equally important part in reducing ripple generated by the inverter due to the unbalanced currents drawn. Since it was shown in the laboratory that the simple filter could ring, a large high-power diode was shunted across the inductor and this provides the required damping.

The second pulse suppressor, shown in figure 3, is essentially a full wave peak rectifier using diodes CR32 and CR33 and reservoir capacitor C2 shunted by resistor R30. In the steady state, the capacitor back voltage almost blocks the two diodes, but when a pulse arrives, one or the other diode fully conducts and the pulse is exposed to the very low resistance path formed essentially by the diode dynamic resistance and the capacitor equivalent series resistance. The consequent high pulse charging current results in a substantial voltage drop across the transformer leakage reactance and asociated resistive paths. After the pulse has finished, the extra charge on the capacitor is quickly dissipated in the shunt resistance and the steady state is re-established. The suppressor has been shown to work well, but it has obvious limitations in regard to the amplitude and time distributions of the transient pulses it can handle.

The search continues for more effective means of transient suppression in high power inverters and the combination of the two methods described give a reasonable measure of protection. Situations that cannot be handled by practical suppressors of this sort or by the new 4-layer diode devices suggest that an inquiry into the transient source itself should be made and appropriate action taken.

If highly rated inverters are to find widespread application in aircraft, the absurdity of one easily suppressed heavy duty relay in the aircraft system demanding complex circuitry in the inverters must clearly be eliminated.

Transistor circuit protection

Experience in the development program has shown that when a power transistor fails it nearly always goes catastrophically short-circuit between the collector and emitter junctions. Associated wiring and components are apt to be very rapidly heated before the usual inverse current relay trips out the dc power. It was considered to be mandatory in this design that such failures could

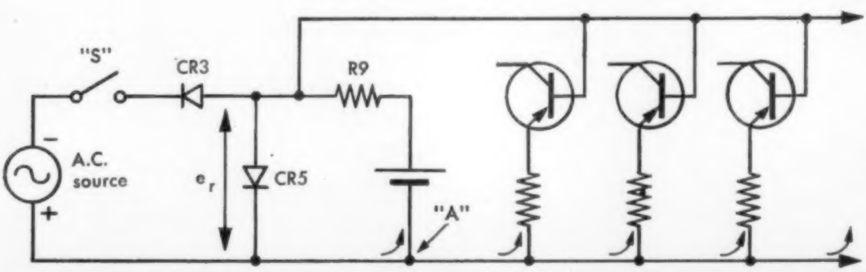


Fig. 5. Circuit detail of second stage amplifier and coupler.

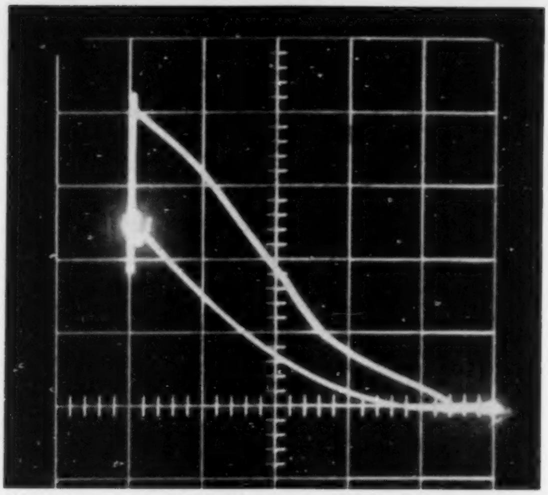


Fig. 6. Dynamic load line of one power stage transistor. Each square represents 10 v horizontally, 2 a vertically.

not produce any kind of hazard. The use of a fuse in series with each transistor tends toward an excessively bulky unit and is ineffective in preventing "chain reaction" failures where transistors fail in rapid sequence due to increasing loading. Additionally, collector-emitter-base shorts, which happen occasionally, quickly degrade the drive circuits, so producing further failures. Clearly, a protective scheme is needed which will trip out the main dc breaker if any transistor in the inverter fails. This requirement has been met by the circuit arrangement shown in figure 7 and involves the use of two small diodes per transistor (except for the oscillator) and a single common high-speed relay. The entire oscillator unit is protected by a single fuse, and if this blows, the dc breaker is also automatically tripped.

In normal operation, a voltage of approximately 2v peak is developed across each emitter resistance, but in the case of a failure this voltage may be expected to rise abruptly. Experiments showed that the resistors used exhibited thermal distress within 30 seconds for a steady applied voltage of 7.0v, and broke down completely within 3 minutes. It was consequently decided to design the safety circuits to operate at 6v maximum and to trip the dc breaker in less than 100ms. Referring to figure 7, it will be noticed that the emitter resistor voltages of all power transistors are routed to the common point "A" through a Zener breakdown diode and a low-power silicon rectifier. The former element senses the abnormal fault voltage, and the latter acts in a decoupling role to prevent interaction among the parallel branches of the circuit.

Very low voltage Zener diodes are characterized by high dynamic resistances which involve much higher fault voltage in order to guarantee operation of the robust type relay to which they are connected. In this application it was shown that additionally a risk of diode failure existed because of transient heating in the fault condition. For these reasons, 6.8v Zener diodes were selected and these have dynamic resistances of only 2 or 3 ohms. In order to ensure the required threshold of operation, with the diodes chosen, the entire group are biased toward the breakdown condition by the rectifier bridge CR10-CR13 which is fed from a 4.0v winding on the oscillator transformer. To break down a Zener diode, and thereby operate the fault relay, an associated emitter voltage of 4-5 volts is required. Immediately the relay operates, contact group RLA applies a negative potential to the relay coil and group RLB joins the other end of the coil to the pilot positive line and consequently the relay is latched on. The RLB contact group also breaks the hold to the main dc power relay, and lights a warning lamp on the cockpit control panel.

As shown on page 21, the aircraft installation comprises a pilot's and co-pilot's windshield and static inverter for each. Should the co-pilot's de-icing system fail, as indicated by the warning lamp, it may be permanently disconnected by manually pulling out the associated dc breaker. If, however, the pilot's windshield system fails, an "emergency" switch permits transfer of the co-pilot inverter to the pilot shield.

Returning to figure 7, it is easily seen that if an oscillator fault develops which blows the fuse, the anode

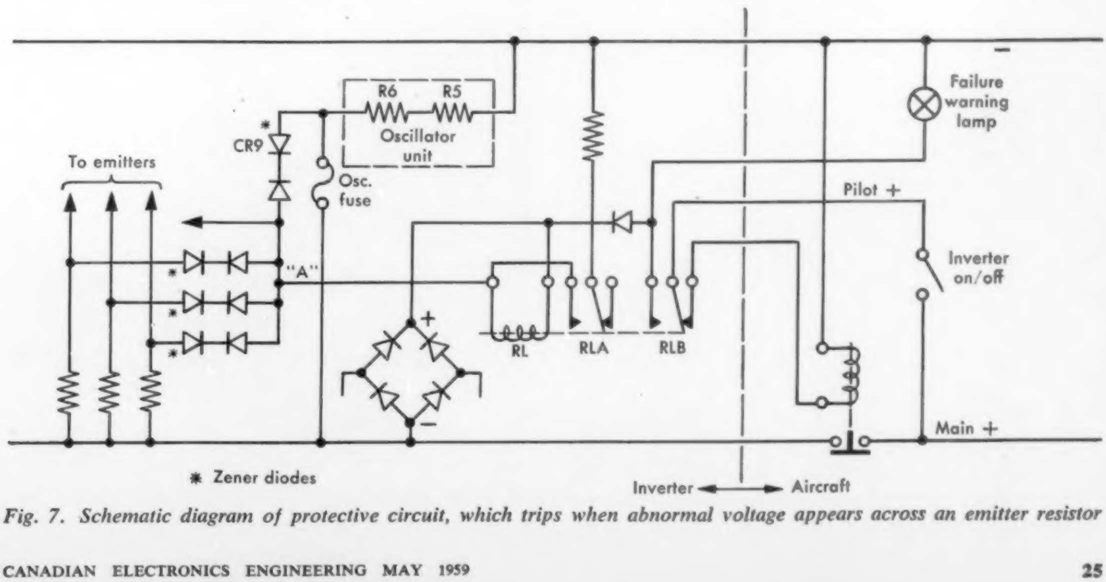


Fig. 7. Schematic diagram of protective circuit, which trips when abnormal voltage appears across an emitter resistor

of diode CR9 becomes negative, through resistors R5 and R6, and the fault relay picks-up, as for the case of excessive emitter voltage. Also, should the bias voltage from rectifier CR10-CR13 fall to zero, the fault protection circuit still works, but at a higher threshold; in this condition it will still respond to practically all failures.

Magnetic protective device

An alternative power stage protector, presently in development, relies on the fact that when a transistor fails, a substantial steady field is set up in the core of the output transformer. The photograph, figure 8, shows how this effect is used. A small wedge-shaped gap is machined in the transformer core at the butt joint and an armature operating a cut-out is located in the gap so formed. At failure, the field attracts the armature to the core and this action trips the main breaker.

Thermometer element fault protection

Further protection to the inverter system is given by using the shape of the first stage magnetic amplifier transfer characteristic to advantage. Should the thermometer transducer become open circuited, the amplifier delivers full output and thereby switches off the second stage and hence the drive to the power stage. On the other hand, should the thermometer be short-circuited, the amplifier delivers a high output in its negative-signal range of operation and once more the drive is reduced to minimum. In both cases, shown in figure 4, a "fail safe to minimum output" condition is achieved.

Construction

Figure 9 shows a general view of the static inverter. This takes the form of a box-shaped enclosure containing all the circuit components with the exception of the power transistors and their emitter resistors. The latter are mounted on a total of 20 aluminum fins, each one being secured to the top of the box with two quick-release screws. All connections to the fins terminate inside the box on a group of bus-bars. The internal arrangement of the components and their mounting means are determined almost entirely by thermal considerations and great use is made of conduction heat-transfer into the inverter base and thence into the aircraft structure. The transistor fins are primarily convection-cooled, but care has been taken to realize the maximum of conduction cooling as well. Heat removal from the highly rated output transformer is accomplished primarily by conduction into the aircraft structure using specially designed core clamps.

Conclusions

The all-up weight of each inverter is just under 20 lb. This is over 30 lb lighter than similar-powered rotary inverters provided with voltage regulators. Measurements show an efficiency of over 75% for this static inverter—much superior to the rotary type—and this, of course, tends to reduce main generation equipment weight and fuel consumption. Freedom from noise, mechanical wear, and regular maintenance are among the other advantages offered. Somewhat on the debit side is the fact that high-power inverters are new additions to the field of aircraft engineering and like any other new commodity have yet to prove themselves by years of trouble-free operation. The enormous strides made in semi-conductor technology, coupled with careful design and the observance of strict quality control procedures in manufacture, will certainly establish high-power inverters over their somewhat more tolerant, but considerably less optimum, rotary counterparts.

Acknowledgments

The author is indebted to The De Havilland Aircraft of Canada, Ltd. for giving permission to publish this article, and also to Messrs. John MacDougall, Lionel Facey and William Dmytrasz of the Guided Missile Division, who participated in the design and development program. END

1. *"A switching transistor dc-ac converter having an output frequency proportional to the dc voltage," G. H. Royer, Trans. paper 55-73, AIEE, February 16, 1955.*

Fig. 8. Magnetic protective device, showing "vee" gap in transformer core and armature, which operates cut-out

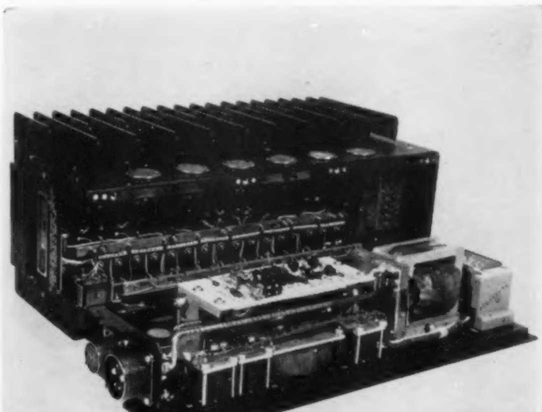


Fig. 9. Photograph of inverter shows main plug-in chassis in foreground, finned enclosure with bus-bars behind

W. J. Bastanier shows Constanta precision resistors to R. J. Hunter

Dr. Sinclair checks booth display with P. Yachimec, J. Hanson and R. G. Sears

C. Spall describes Cominco high purity metals and alloys

Canadian firms must find new markets

IRE Convention and AtomFair show new trend

IAN R. DUTTON, ASSOCIATE EDITOR

This year a number of Canadian electronics companies must revise their marketing plans. Their traditional markets have changed — or disappeared — and now they must do some fast footwork if they want to stay in the running.

The major shift is coming in military electronics. With almost complete integration of Canadian defense operations with those of the United States, very few research or manufacturing contracts will originate here. Canadian companies must get out and sell their products and services to the American authorities and prime contractors.

The reduced market for military electronics in Canada has prompted some manufacturers to take a closer look at industrial electronics. Most of them are convinced that the long-term prospects are good. The surface has just been scratched and there will be many opportunities for anyone with initiative.

To see what can be expected in the near future, and what the Canadian companies are doing to prepare for it, our editorial staff has attended the major conventions this spring.

IRE National Convention

When the IRE Canadian Convention first started in 1956 a number of companies here stopped displaying at the National Convention because they felt that their money would be better spent by concentrating their sales effort in Canada. In brief, they were not interested in selling to the U. S. market — perhaps because they thought they couldn't compete there with any success.

This year may be the turning point. Four Canadian companies exhibited at the show in New York. In addition, some sales engineers were seen talking to prospective American buyers.

One of the exhibitors, Sinclair Radio Labs. Ltd., has taken a positive step into the American market. It has established a new division, Sinclair Radio Laboratories, 412 Chamber of Commerce Building, Buffalo 2, N.Y.

When interviewed on the opening morning of the convention, Dr. Sinclair held no illusions of quick success. He anticipated a long slow climb ahead, but was prepared to move into this market with his commercial antennas and instruments.

His philosophy appears to be quite sound. American customers dislike having to deal with customs problems. They do much less importing than Canadians and are not familiar with the regulations. After all, why should they seek added complications when they can find suppliers within their own country?

With his company in Buffalo, Dr. Sinclair will be able to offer his products to American buyers without handing them the customs problems too. This is a lesson that other Canadian companies could remember.

The other three Canadian companies at the IRE show were repeat exhibitors. The Consolidated Mining & Smelting Co. of Canada Ltd. has been quite successful in selling its products in the United States. Their display featured indium metal and fabricated shapes; high purity lead, cadmium, bismuth, zinc, silver, tin and antimony.

Mr. and Mrs. Bastanier of Constanta Co. of Canada, Ltd. have been selling their high stability precision resistors to American buyers for a number of years now. Their new products attracted several promising enquiries during the show.

The people from E.M.I.-Cossor Electronics Ltd. had a busy time. Besides manning their own booth at the show, they helped out at the Henry Hudson Hotel where E.M.I. equipment was being displayed by H. L. Hoffman and Co. At the hotel they demonstrated their Percival stereo radio system. Considering the conditions under which they worked, the reproduction sounded very good and proved that the system would be a strong contender in the approaching struggle for the stereo radio market.

Harold Price (r) checks a connector at U. S. Components booth with their Canadian representative J. J. McQuarrie

D. Snell of A. T. R. Armstrong Ltd. gets latest news on rectifiers at booth of his principal, Sarkes Tarzian Inc.

R. D. B. Sheppard gets right down to work when visiting G. Keyarts at the Fairchild Semiconductor Corp. booth

A. N. Dugar shows latest Kemtron Catalog to Miss James, F. Taylor, R. Turner and A. Ainley of Lake Engineering.

Dr. W. Clarke (centre) assists visitors taking close look at products in booth of E.M.I.-Cossor Electronics Ltd.

The E. M. I. Percival system adapts am and fm transmitters for stereo broadcasting. Visitors were impressed.

As in previous years, a number of Canadian representatives visited the IRE show. Some were looking for new principals, while others were busy helping to man the booths of their existing principals.

The Technical Materiel Corp. featured their general purpose 10-kw transmitter model GPT-10,000. It is the same type that has just been shipped to the Dominion Observatory, Ottawa, for their time service station CHU. It will replace a smaller transmitter formerly used, and will operate on 14.670 mc at 10 kw PEP. V. E. Hollingsworth of the Observatory Time Service visited the Technical Materiel Corp. plant at Mamaroneck, N.Y., during the IRE show.

In a show the size of the IRE National Convention it is difficult to ferret out the truly significant news. Every exhibitor has something worth showing, but it would be impossible to describe everything in one report.

One significant new product seen at the show was a dc motor with a printed-circuit armature. It was invented by F. H. Raymond and J. Henry-Baudot of SEA, Paris. American patents are held by Printed Motors, Inc., who will license interested manufacturers in the United States and Canada. Shaft outputs from a few watts to several kilowatts are claimed to be possible.

Nuclear Congress

One of the more pleasant surprises this spring was the Canadian participation at the AtomFair in Cleveland. Twenty companies exhibited, and the majority of them were pleased with the response from prospective American and European buyers. While many of the American companies displayed components for research or experimental nuclear reactors, the Canadians concentrated on commercial and industrial applications such as instruments, isotopes, medical equipment and commercial power reactor components.

Mr. Humphries has a busy time at the Electronic Associates Ltd. booth explaining their industrial control equipment utilizing isotopes. He was impressed by the way in which American engineers tended to add unnecessary complications into problems and designs. Many instances can be found where Canadians have taken a more direct approach, resulting in reliable equipment.

Industrial Instrumentation Conference

The Armour Research Foundation and the IRE Professional Group on Industrial Electronics held a conference in Chicago last month on industrial instrumentation and control. They took stock of their present position, and a good long look at what will be coming in the future.

New equipment designs will eliminate the human operator, particularly in the on-stream type of process control. Outputs will be sampled, the data fed through data-handling equipment to central computers. These in turn will feed signals to the control circuits that apply corrections to the processing equipment.

Some examples of industrial applications of electronics were seen at the National Packaging Exposition, Chicago. Transducers were used to weigh bulk material for packaging. Timers operated equipment, photoelectric cells counted packages and tablets, and electrostatically charged powder helped to dry ink on printed material.

There is a growing market for industrial electronics, both in Canada and the United States. However, Canadian companies must face up to the problems of a competitive market and get out to sell.

(Note for the design engineer: a good product is an essential starting point.)

(Note for all engineers and managers: the National Industrial Production Show of Canada will be held in Toronto, May 4-8, 1959.) END

A. Sheffield of TMC (Canada) Ltd. shows 10 kw transmitter to V. E. Hollingsworth of Dominion Observatory. Same type being installed at CHU, Ottawa, for time service

Industrial electronics: Photocell controls label applicator on Minnesota Mining & Manufacturing Co. machine

A new design: Motor armatures can now be made in the form of printed circuits. This one is rated at 30 hp

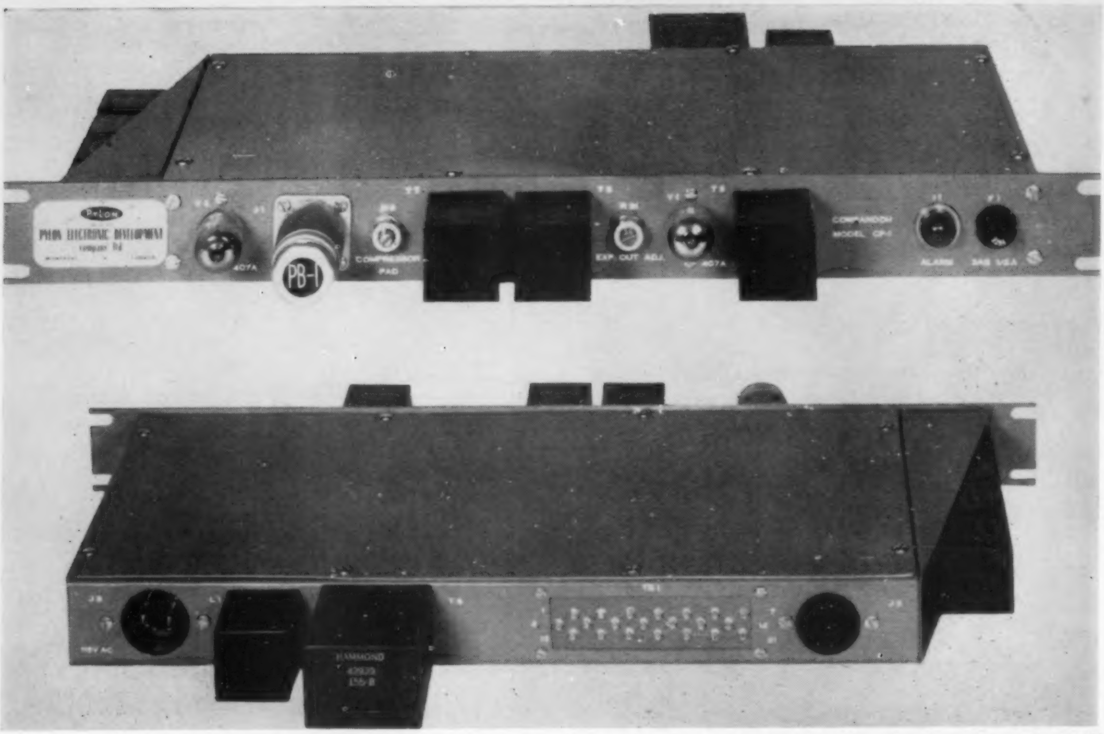


Fig. 1. Front and rear views of typical modern compandor, designed and manufactured in Canada. Height is only 1¾"

How compandors improve voice circuits

STANLEY E. A. PINNELL, MSC*

Compandors can give a considerable improvement in voice circuit signal-to-noise ratios at reasonable cost. Their operation is explained with reference to charts showing their effect on signal and noise levels. Notes are included on their application in radio relay systems, and the gain adjustments required in single- and multi-channel systems

A major problem facing the communication system planner is that of achieving a satisfactory compromise between economic considerations on the one hand and the grade of service desired on the other. The advantages of adequate signal-to-noise ratio in reducing user service reaction are well known for voice systems. However, high circuit quality is costly, particularly in Canada where many lengthy circuits carry relatively light traffic. Where these are of marginal quality, extensive and costly line work may be required to maintain a proper service level. Such expense may also be incurred when services are expanded. The addition of extra channels to existing facilities forces a reduction in transmit gains to avoid overload, with a corresponding reduction in circuit quality. At the same time cross-talk which exceeds desired standards may be introduced so that costly retranspositions may also be required.

Economics can also weigh heavily against adequate quality where the system involves radio circuits. This is particularly true if a radio link has been stretched out to the maximum in distance. Once a certain level of transmitter power, antenna gains and tower heights has been reached, the cost of further improvement in signal-to-noise ratio is out of all proportion to the benefit obtained. Radio circuits may be stretched out to this extent where a long hop is required over water or a lengthy overland link has no suitable site for an intermediate repeater which is accessible on a practical basis.

In each of these cases the use of compandors can result in a substantial gain in quality at a considerable saving in cost in comparison with more direct methods. A thorough knowledge of the compandor and its principles of operation is desirable, therefore, to enable the planner to determine the advantage to be expected from its use in a particular situation.

The compandor is a device for processing speech signals

*Pylon Electronic Development Co. Ltd., Montreal

to a form more suitable for electrical transmission. It consists of two sections: the compressor at the transmitting terminal which operates on the incoming signals to reduce their dynamic range, and the expandor at the receiving terminal which reproduces the original signals. The compandor manufactured by Pylon is designed for general usage on existing or new facilities whether single or multiple channel. Designated the CP-1, the unit comprises a complete compandor terminal with transmit compressor, receive expandor, and ac-operated power supply. One unit at each end of a voice circuit provides full compandor action for both directions of transmission.

As shown in figure 1, the CP-1 occupies 1¾ in. of space on a standard 19-in. rack and extends 3 in. forward. Two vacuum tubes are required and there are only two operational settings. The compandor is put in service by plugging in ac power and the signal and alarm lines. Strapping terminals are provided at the rear of the unit to adapt it to various operating conditions and a built-in hybrid permits direct use on two-wire drops. A separate bridging plug in the front panel may be removed for routine test purposes or to permit patching between channels. The ac main is equipped with a fuse, failure of which lights a panel lamp and reports an alarm condition through an internal relay.

Logarithmic compression

A block diagram of a compandor is shown in figure 2. At the input to the compressor there is a variable loss element, the loss of which is controlled by the output from the compressor. The control function of the variable loss device is designed to give a logarithmic compression characteristic such that the output from the compressor will change by 1 db for a 2 db change of input. The receiving expandor also includes a variable loss element located at the input side of the expandor amplifier. The gain of this variable loss device is controlled by the power of the received signal, the expansion characteristic being designed to give a 2 db change of output for each 1 db change of input.

The effect of the compandor on voice signals is illustrated graphically in figure 3. Here a 50 db range of input signals is compressed to a 25 db range for transmission and then expanded at the receiving terminal to the original range. The effect on weaker signals is that they are transmitted at higher power relative to the noise and interference of the transmission facility. The net result of this action is an over-all improvement in apparent, or usable quality. The circuit behaves in every sensible way as if there had been a substantial increase in signal-to-noise ratio.

There is a tendency to view compandor action with a certain amount of suspicion in the belief that it represents an attempt to get something for nothing. In reality, it is a form of information processing which permits improved transmission efficiency. Compandor action is quite in accord with modern transmission theories which indicate that the results obtained from a channel can depend markedly on how it is used, and in particular, on the type of information being carried and the way it is processed for transmission.

Wide dynamic range

Information in the form of normal voice signals is particularly costly to communciate. This is because the dynamic range of signals is high compared with the rate at which information can be passed. There are many speech sounds which require a high peak power as compared with the average voice volume. In addition, the transmission capacity of a voice channel must accommodate the variations in average volume among different individuals. Average subscriber talking volume is generally

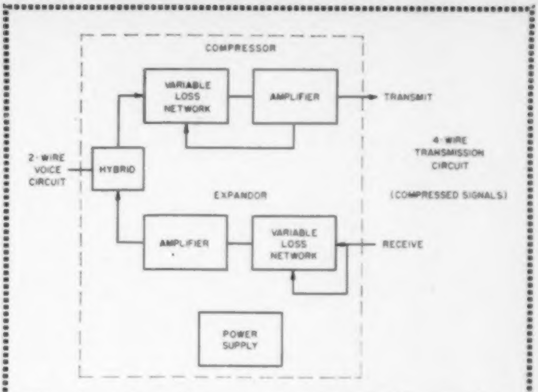
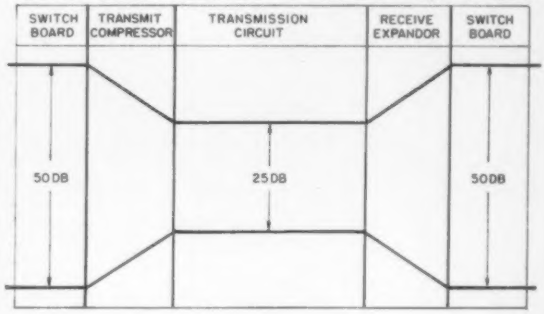


Fig. 2. Block diagram of a compandor terminal

Fig. 3. Effect of compandor on dynamic range of signals



taken to be about —15 vu. For soft talkers the average volume can fall to —24 vu and for very loud talkers the average volume may be as high as 0 vu. A circuit which does not provide for all these variations will require undue concentration in transmitting and receiving in order to achieve proper intelligibility. An over-all standard of quality which is often applied to long distance circuits requires that a 40 db ratio of zero level test signal to weighted noise plus crosstalk be maintained for at least 99% of the busy hour.

In some cases it is possible to meet this standard of quality on circuits with relatively high noise by raising the transmit gain. The signal-to-noise ratio of a linear transmission circuit is improved in direct proportion as the transmit gain is raised and a corresponding loss inserted at the receiving end. In many circumstances, however, it is impossible to raise the transmit gain because of limitations in cross-talk and distortion or the possibility of overmodulation of radio equpiment. If quality standards are not met in such cases, lower volume speech sounds will be lost in the noise. This is particularly true for average or soft talkers who may become unintelligible.

The compandor overcomes this problem by raising transmit gains for the weaker signals while speech peaks are kept within the power capacity of the channel. The resultant noise improvement is shown diagrammatically in figure 4. Here two switchboard tone powers are considered, 0 and —24 dbmo, and a comparison is made between the received signal and noise powers for normal transmission and for transmission over a circuit equipped

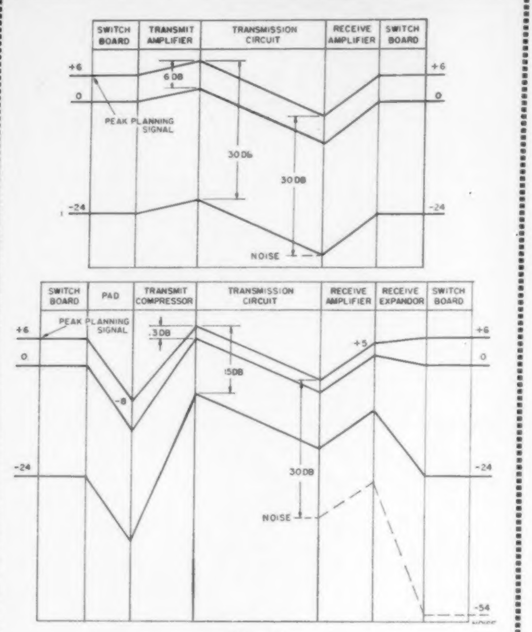


Fig. 4

Effect of compandor on signal and noise levels. Upper diagram — levels in a standard circuit. Lower diagram — levels in a compandored circuit

Interfering tone level dbmo	Observed compandor s/n improvement			Relative suppression of interfering tone in the absence of speech db
	Speech volume —24vu	Speech volume —16vu	Speech volume Ovu	
— 9		14	11	15
—14	18	17	14	20
—19	22	20	18	25
—24	25	23	21	30
—29	28	27	24	35
Relative suppression of interfering tone during steady signal corresponding to test speech volume db.	15	11	3	

Table I.

with compandors. In both cases the relative noise power at the receiving terminal is assumed to be —24 dbmo and the circuits are designed for peak signals up to +6 dbmo.

In the case of normal transmission, a tone input at 0 dbmo is received at a level of 24 db above noise. An input tone at —24 dbmo is reproduced at —24 dbmo which is equal to the output noise of the receiver amplifier.

In the compandored circuit, the net gains are the same as before for the peak planning signal only. The net gains for weaker signals are raised all along the compressed section of the circuit.

In the example shown, the net gain at any point along the compressed portion of the circuit is 3 db higher for the 0 dbmo tone and 15 db higher for the —24 dbmo tone. The 0 dbmo tone is now received at 27 db above noise and after expansion is heard at 54 db above background noise. The —24 dbmo tone is received at 15 db above noise and after expansion is heard at 30 db above background noise. Consequently, there is a very considerable improvement for this tone in the ratio of received signal to received background noise, the total improvement being 30 db.

However, it must be borne in mind that during transmission of a tone the receiving gain is raised due to expandor action, consequently the output noise is higher than the background noise found in the absence of signals. During transmission of the 0 dbmo tone the output noise rises to —27 dbmo and to —39 dbmo during transmission of the —24 dbmo tone. Corresponding improvement figures are 3 db and 15 db. If, however, both tones were transmitted simultaneously, the gain of the expandor would be set by the total signal power which in this case is that of the higher power tone. The improvement for both tones would be only 3 db.

From a study of figure 4 it is apparent that the improvement obtained is a function of the received signal and noise powers. In addition, its dependence upon the complex structure of the signal has been indicated. However, it is not possible to build up in this way a simple theoretical means of predicting improvement for voice signals where the compressor gain and expandor loss are varying continuously. Furthermore, in order to assess speech improvement, the characteristics of the human ear and the psychologcial mechanism of hearing must be taken into account. For example, during transmission of a loud tone the background noise is raised by expandor action but there is little audible effect since it is masked by the received tone. Again, when there is no speech present the expandor is restored to the condition of maximum loss and the ear receives a minimum of distracting interference. For these reasons the actual improvement to be expected under a variety of conditions can only be determined properly by listening tests.

Typical results of tests made to determine compandor improvement using different talking volumes and different background tone interference powers are shown in table 1.

Shown with the observed improvements are the improvements in the absence of speech and the improvements during transmission of steady signals corresponding to the speech volumes used in the tests. It is seen that the listener tends to perceive relative interference somewhat closer to that heard in the absence of signal than would be heard during transmission of a steady signal corresponding to the test speech volume. This result shows the contribution made by the expandor in noise suppression — the observed improvement after expansion is greater than would be measured on a tone basis at the expandor input.

As expected from figure 4, the observed improvement is greater for soft talkers and for quieter circuits. A figure which is often quoted for compandor improvement is 22 db, corresponding to the improvement for an average talker on a circuit with background interference at —24 dbmo. This is a representative figure which is recommended for planning purposes.

Radio relay systems

Compandor improvement is particularly valuable in connection with radio relay systems, where it may lead to useful savings by cutting down the number of repeaters necessary to cover a given distance, or by permitting the use of smaller antennas or lower towers on long hops. Again, for a given type of equipment it can mean that more relay stations may be strung out in series before exceeding cross-talk and noise limits. For any type of system, because of the reduction in cross-talk and distortion probabilities, the use of compandors can mean cheaper filtering equipment and reduced maintenance costs because of relaxed alignment requirements.

A number of points should be borne in mind, however,

in applying compandors to a system:

The compandor is intended for 4-wire voice circuits which may be physical, phantom, carrier derived or radio transmission circuits. When arranged to operate between 2-wire drops by means of the built-in hybrid, the effect of compandor action is to reduce the singing margin for the circuit, particularly where there is a high transmission loss. In planning such applications, the need for a higher than usual singing margin should be recognized.

Obviously, compandor action will not affect noise which is introduced at the input side of the compressor, this being reproduced at its original level after expansion. The improvement obtained is in the actual quality of the transmission facility so as to reduce the effects of transmission noise and cross-talk as well as power line induction. On the other hand, the effects of gain variations in the transmission channel are magnified by the expandor. For example, if the gain of a radio transmission circuit were to fall by 2 db over a given period of time, the observed gain variation after expansion would be 4 db. Finally and most important, it is necessary that the inputs to the compressor and the expandor be properly set. This situation is brought about because both elements have a limited dynamic range in which the compression and expansion ratios are accurate. Outside this range abnormal transmission characteristics occur.

Gain adjustment

The adjustment of gains is quite easy and readily understood. In single-channel system planning, provision should be made at the transmit terminal to feed the peak planning signal into the compressor at its maximum recommended input, which in the case of the CP-1 is —8 dbm. The gain of the compressor for this peak signal should be planned to give the same peak signal power into the transmission facility as if the circuit were not compandored.

At the receiving terminal, the output of the receiving equipment should be arranged so that at peak planning signal it is equal to the maximum recommended input for the expandor which is +5 dbm. The output from the expandor can then be adjusted downward to any convenient value, since it has no effect on dynamic range.

While the settings are laid out on a planning basis in terms of the peak planning signal, they would actually be set in the field and tested by means of standard 0 dbmo test tone. When making such settings, it is necessary to allow for an increase in net gains along the circuit where the signals are compressed. In the circuit of figure 4 the net gains for the 0 dbmo tone are increased by 3 db in the compressed portion of the circuit, and the corresponding increase for the circuit of figure 5 is 5 db.

The important and fundamental point in system planning is that the peak planning signal is transmitted at the peak input power permissible for the facility. The latter is the same whether the signals are compressed or not.

Multichannel systems

This statement is strictly correct for single channel circuits only. In multichannel systems, compression of voice signals in the individual channels results in a slight increase in power of the complex signal and the individual channel gains must be reduced to offset this effect. This reduction is not serious even for large numbers of channels. This is because the action of the compandors in the individual channels is to provide the greatest increase in net gain for the weakest signals which contribute negligibly to the complex signal power. At the same time maximum signals, which largely determine the total power, have the same net gains whether compandors are used or not. Actual experience shows that the amount of gain reduction required is less than 6 db for even large numbers of channels. Thus, taking the figure of 22 db as a planning estimate for compandor improvement on a single channel circuit, the corresponding figure for a multichannel system is at least 16 db for ten or more channels. This improvement is satisfactory for many applications.

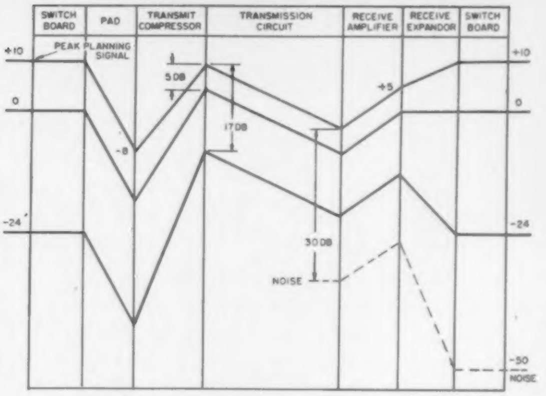


Fig. 5. Effect of compandor on signal and noise levels. Levels in a compandored circuit designed for peak signal 10 db above zero level

The point is sometimes raised whether compandor gain settings made on a test tone basis are accurate for complex voice signals. This depends on the partciular compandor control circuits. Measurements to determine the effect of wave shape on net gains taken on the compressor of the CP-1, show the following results:

Signal	Input	Output
Square Wave	—15 dbm	+2.8 dbm
Test Tone	—15 dbm	+2.5 dbm
White Noise	—15 dbm	+2.2 dbm

The above measurements were made on a true power basis and show that the test tone settings are accurate for steady complex signals. There is substantially no change in gain for the different inputs which encompass a considerable variation in waveshape as defined by the peak-to-rms ratio of the signal.

Of course, this would not be the case if the measurements were made with a vu-meter, standard transmission test set or other waveshape sensitive device. Measurements made using test tone, on the other hand, are independent of meter characteristics, and should be used in testing and setting net gains for a campandored system. END

Any comments?

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The transistor as a 4-terminal network

M. A. GULLEN, P.ENG*

In Part 1 (CEE, April 1959, page 25) the author showed how to construct curves derived from the admittance parameters of a quadripole. This part shows how curves may be drawn to derive information on voltage, current and power gain characteristics, illustrated by application to a transistor

Part 2: Gain considerations

In the general network of Figure 1 the forward and reverse voltage gains are given by

$$\gamma_f = \frac{v_2}{v_1} = -\frac{Y_{21}}{Y_{22} + Y_L} \quad \ldots\ldots\ldots (7)$$

$$\gamma_r = \frac{v_1}{v_2} = -\frac{Y_{12}}{Y_{11} + Y_g} \quad \ldots\ldots\ldots (8)$$

Relations involving the forward voltage gain, γ_f, only, are hereinafter considered. Equivalent relations for the reverse voltage gain, γ_r, may be obtained by simple substitution of subscripts.

The phase angle of the voltage gain, θ_f, is given by

$$\tan \theta_f = \frac{xp - 1}{x + p} \quad \ldots\ldots\ldots\ldots (9)$$

where $$x = \frac{a_{22} + a_L}{b_{22} + b_L}, \quad \text{and } p = \frac{b_{21}}{a_{21}} \quad \ldots\ldots (9a)$$

It follows that

$$a_L = -(b_{22} + b_L)\left[\frac{p \tan \theta_f + 1}{\tan \theta_f - p}\right] - a_{22} \quad \ldots (10)$$

The locus of constant phase angle in the a_L, b_L plane is a straight line passing through the point $(-a_{22}, -b_{22})$. The line corresponding to a phase angle θ_f is orthogonal to the line corresponding to a phase angle of $(90° + \theta_f)$, and the angle, ϕ, between lines corresponding to phase angles θ_{f1} and θ_{f2} is given by

$$\phi = \theta_{f2} - \theta_{f1} \quad \ldots\ldots\ldots\ldots (11)$$

Thus, if the line corresponding to zero phase angle is plotted in the a_L, b_L plane, and a second line, corresponding to an arbitrary phase angle, is plotted to establish the sense of the rotation, then the line corresponding to any other desired phase angle may be laid in with a protractor.

From equation (7), the condition that θ_f is a first quadrant angle is given by

$$a_{21}(b_{22} + b_L) \geq b_{21}(a_{22} + a_L) \quad \ldots (12)$$

and $$-a_{21}(a_{22} + a_L) \geq b_{21}(b_{22} + b_L) \quad \ldots (12a)$$

As the line corresponding to θ_f passes through the point $(-a_{22}, -b_{22})$ the terms $(a_{22} + a_L)$, $(b_{22} + b_L)$ will change sign. The line, then, will correspond to θ_f on one side of $(-a_{22}, -b_{22})$ and to $(180° + \theta_f)$ on the other side.

The magnitude of the voltage gain, (γ_f), where the brackets denote magnitude only, is given by

$$(a_{22} + a_L)^2 + (b_{22} + b_L)^2 = \frac{(Y_{21})^2}{(\gamma_f)^2} \quad \ldots (13)$$

The locus of constant magnitude of forward voltage gain in the a_L, b_L plane is a circle centred at $(-a_{22}, -b_{22})$ of radius

$$R = \frac{(Y_{21})}{(\gamma_f)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (13a)$$

An example of the voltage gain curves for 2N123 is given in Figure 7. The similarity of the curves to the M and N contours of the inverse closed-loop frequency response employed in servomechanism analysis may be noted.

Current gain

In the general network of Figure 1 the forward and reverse current gains are given by

$$\alpha_f = \frac{i_2}{i_1} = \frac{Y_{21}\, Y_L}{Y_{11}(Y_{22} + Y_L) - Y_{12}\, Y_{21}} \quad \ldots (14)$$

$$\alpha_r = \frac{i_1}{i_2} = \frac{Y_{12}\, Y_g}{Y_{22}(Y_{11} + Y_g) - Y_{12}\, Y_{21}} \quad \ldots (15)$$

If the load, or generator, is a short circuit, (infinite admittance) these expressions reduce to

$$\alpha_{fo} = \frac{Y_{21}}{Y_{11}}, \qquad \alpha_{ro} = \frac{Y_{12}}{Y_{22}} \quad \ldots\ldots\ldots (16)$$

The short circuit forward current gain is termed the alpha or beta of the transistor depending on whether a common base or common emitter configuration is considered.

In the following only the forward current gain will be considered. Equivalent expressions for the reverse current gain may be obtained by simple substitution of subscripts.

Expressions are simplified by employing secondary parameters defined as

$$u = a_{11}\, a_{21} + b_{11}\, b_{21} \quad \text{and } w = a_{11}\, b_{21} - a_{21}\, b_{11} \quad . (17)$$

$$n = a_{22}u + b_{22}w - a_{12}(Y_{21})^2 \quad \ldots\ldots\ldots\ldots\ldots (17a)$$

and

$$m = a_{22}w - b_{22}u + b_{12}(Y_{21})^2$$

The tangent of the phase angle of the forward current gain is given by

$$T = \frac{(a_L^2 + b_L^2)\, w + a_L m + b_L n}{(a_L^2 + b_L^2)\, u + a_L n - b_L m} \quad \ldots\ldots (18)$$

It follows that the locus of constant phase angle in the

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*Army Developement Establishment, Ottawa.

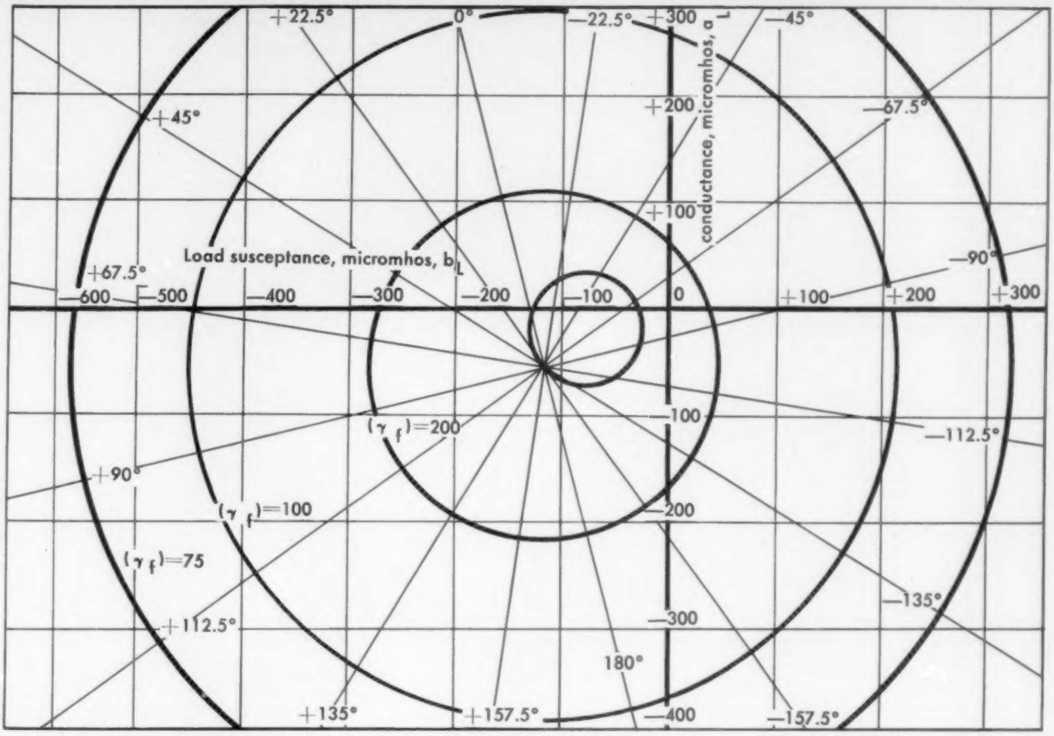


Fig. 7. Forward voltage gain — load admittance curves of 2N123 common base transistors at 398 kc.

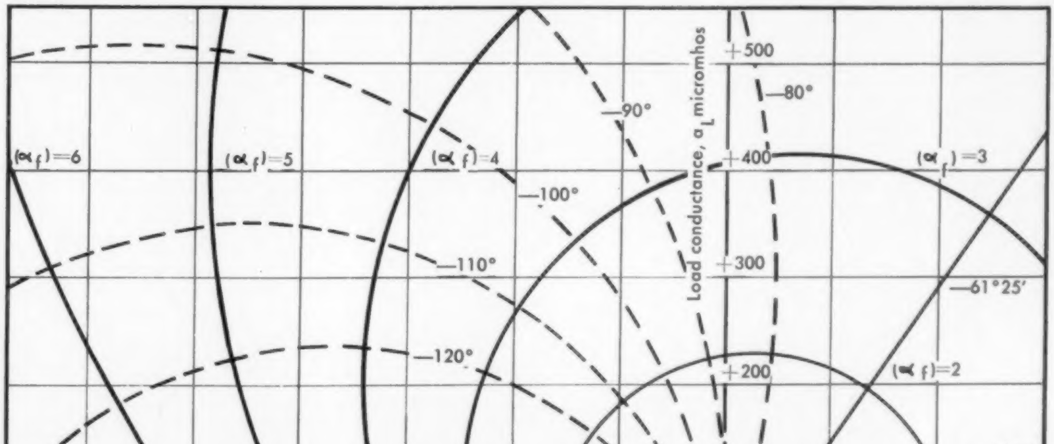


Fig. 8. Current gain — load admittance curves of 2N123 common emitter transistors at 1114 kc.

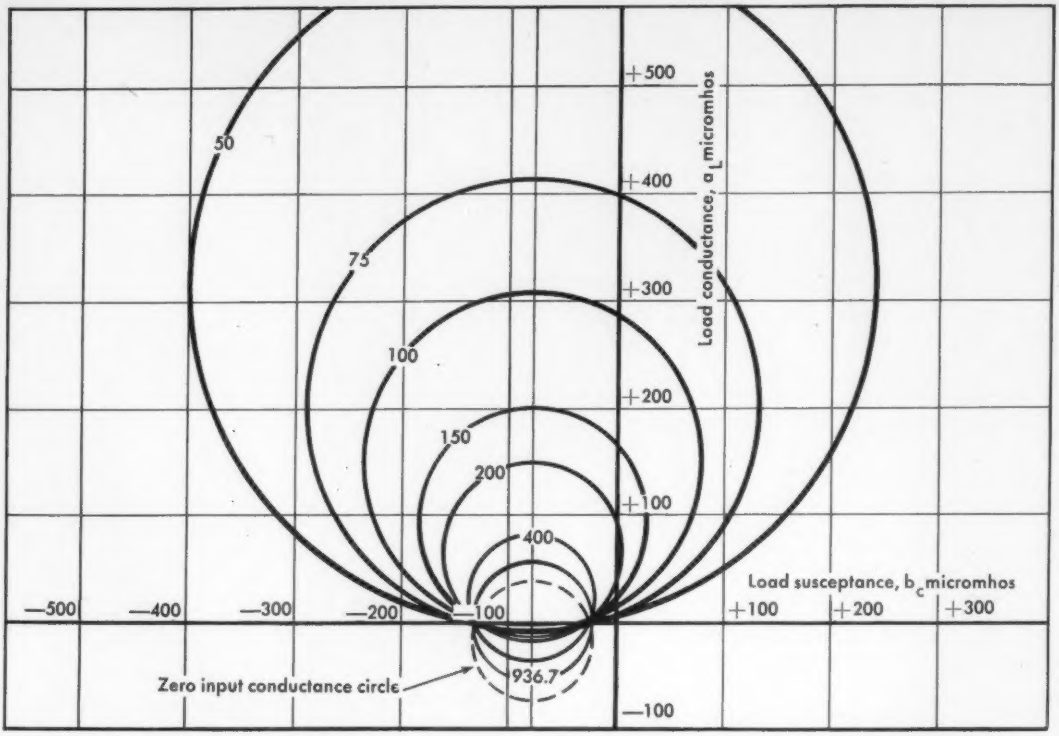


Fig. 9. Power gain — load admittance curves for 2N123 common base transistors at 398 kc.

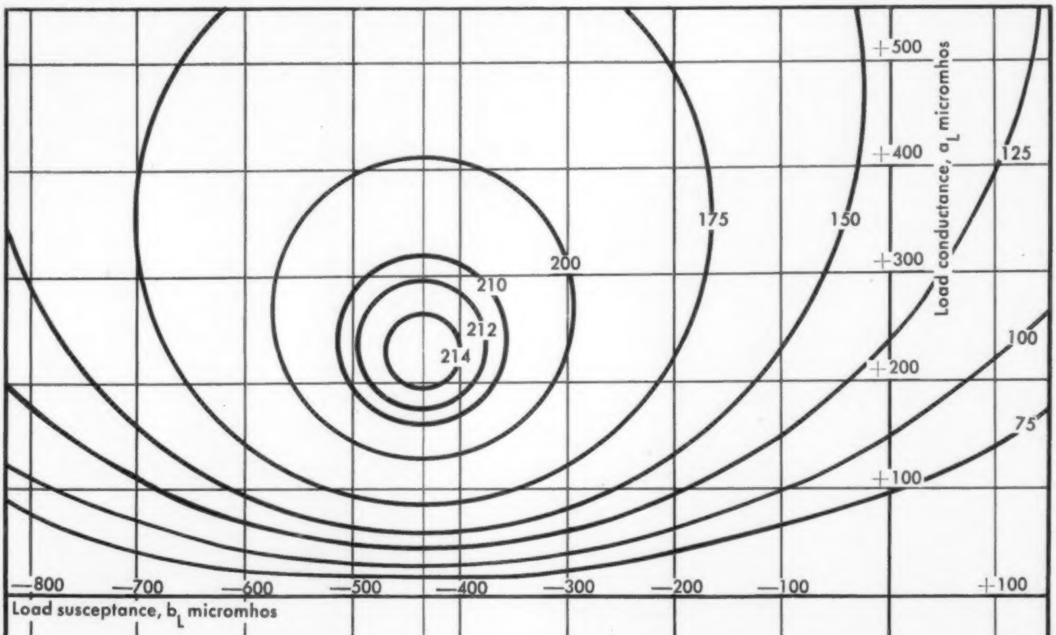


Fig. 10. Power gain — load admittance curves for 2N123 common emitter transistors at 1114 kc.

a_L, b_L plane is a circle whose centre co-ordinates are

$$a_L = \frac{1}{2}\left[\frac{m - Tn}{Tu - w}\right] \text{ and } b_L = \frac{1}{2}\left[\frac{n + Tm}{Tu - w}\right] \quad (18a)$$

and the square of whose radius is

$$R^2 = \frac{(T^2 + 1)(n^2 + m^2)}{4(Tu - w)^2} \quad \ldots\ldots\ldots(18b)$$

It can be shown that the centres of the circles of constant phase lie on a straight line given by

$$a_L = b_L\left[\frac{um - wn}{wm + nu}\right] - \left[\frac{m^2 + n^2}{2(wm + nu)}\right] \quad .(18c)$$

and, furthermore, that all circles intersect the origin and the point

$$a_L = -\left[\frac{wm + nu}{u^2 + w^2}\right], \quad b_L = \left[\frac{um - wn}{u^2 + w^2}\right] \quad .(18d)$$

Referrring to (18), the numerator may be written

$$N = w\left[(a_L^2 + b_L^2) + \frac{m}{w}a_L + \frac{n}{w}b_L\right] \quad \ldots(18e)$$

The bracket term, if equated to zero, represents a circle in the a_L, b_L plane whose centre co-ordinates are

$$a_L = -\frac{m}{2w}, \quad b_L = -\frac{n}{2w} \quad \ldots\ldots(18f)$$

and whose radius is

$$R = \frac{1}{2w}\sqrt{n^2 + m^2} \quad \ldots\ldots\ldots\ldots(18g)$$

It is, in fact, the circle corresponding to $T = 0$. For points inside the circle, on the circle or outside the circle, and depending on the sign of w, the numerator will be negative, zero or positive. Treating the denominator similarly

$$D = u\left[(a_L^2 + b_L^2) + \frac{n}{u}a_L + \left(-\frac{m}{u}\right)b_L\right] \quad ..(18h)$$

The bracket term equated to zero corresponds to the circle for T = infinity and for points inside the circle, on the circle or outside the circle, and depending on the sign of u, the denominator will be negative, zero or positive. The quadrant in which the phase angle lies is thus determined.

The simplest expressions from which the magnitude of the current gain may be calculated are (14) and (15). It may be shown that the locus of constant magnitude of forward current gain, (α_f), in the a_L, b_L plane is a circle whose centre co-ordinates are

$$a_L = -\frac{(un + wm)}{(Y_{21})^2} \cdot \frac{(\alpha_f)^2}{(\alpha_f)^2(Y_{11})^2 - (Y_{21})^2} \quad (19a)$$

$$b_L = -\frac{(wn - um)}{(Y_{21})^2} \cdot \frac{(\alpha_f)^2}{(\alpha_f)^2(Y_{11})^2 - (Y_{21})^2} \quad (19b)$$

and whose radius is

$$R = \frac{(\alpha_f)\sqrt{m^2 + n^2}}{(\alpha_f)^2(Y_{11})^2 - (Y_{21})^2} \quad \ldots\ldots(19c)$$

and, further, that these centres lie on a straight line

$$a_L = \frac{(un + wm)}{(wn - um)}b_L \quad \ldots\ldots\ldots(19d)$$

which passes through the origin and intersects, orthogonally, the line of centres of the circles of constant phase angle, (18c), at the point

$$a_L = -\left[\frac{(un + wm)}{2(u^2 + w^2)}\right] \quad b_L = -\left[\frac{(wn - um)}{2(u^2 + w^2)}\right] \quad (19e)$$

The line, (18c), is not a tangent line to the family of circles of constant magnitude of current gain, but is the locus of constant magnitude of current gain (α_{fo}).

An example of the current gain loci, for 2N123, is given in Figure 8. The similarity of these curves to the M and N contours of the direct closed loop frequency response employed in servomechanism analysis may be noted. Such curves may show the rather surprising feature that for some values of load, with a positive conductance component, a junction transistor may exhibit a current gain greater than unity in the common base configuration. The load will have a negative susceptance component. The output susceptance forms a resonant tank with the load susceptance. A current gain greater than unity simply indicates that the tank circulating current is greater than the generator, ie the transistor, make-up current.

Inspection of equation (14), shows that when

$$Y_{22} + Y_L = \frac{Y_{12}\,Y_{21}}{Y_{11}} \quad \ldots\ldots\ldots(20)$$

the denominator is zero and the magnitude of current gain becomes infinite. But, under these conditions, the input admittance is zero and there is zero input current.

Power gain

The ratio of the power output, $v_2^2\,a_L$, to the power input, $v_1^2\,a_{in}$, the power gain, is

$$G = \frac{v_2^2\,a_L}{v_1^2\,a_{in}} = (\gamma_f)^2\frac{a_L}{a_{in}} \quad \ldots\ldots\ldots(21a)$$

Substituting expressions for the voltage gain and the input conductance yields

$$G = \frac{a_L\,(Y_{21})^2}{a_{11}} \cdot \frac{1}{(a_L + \frac{1}{2}A)^2 + (b_L + \frac{1}{2}B)^2 - \frac{(Y_t)^2}{4a_{11}^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(21b)$$

$$\text{Where } A = 2a_{22} - \frac{a_t}{a_{11}} \text{ and } B = 2b_{22} - \frac{b_t}{a_{11}} \quad \ldots(21c)$$

The denominator of the second term, equated to zero, gives the zero input conductance circle. The gain becomes indeterminate at the zero input conductance circle since the input power is zero. The term involving b_L is always positive. If there is a maximum on the gain surface it will occur on the plane,

$$b_L = \frac{b_t}{2a_{11}} - b_{22} \quad \ldots\ldots\ldots\ldots(21d)$$

If this restriction on b_L is imposed and the gain is differentiated with respect to load conductance a stationary value is found when

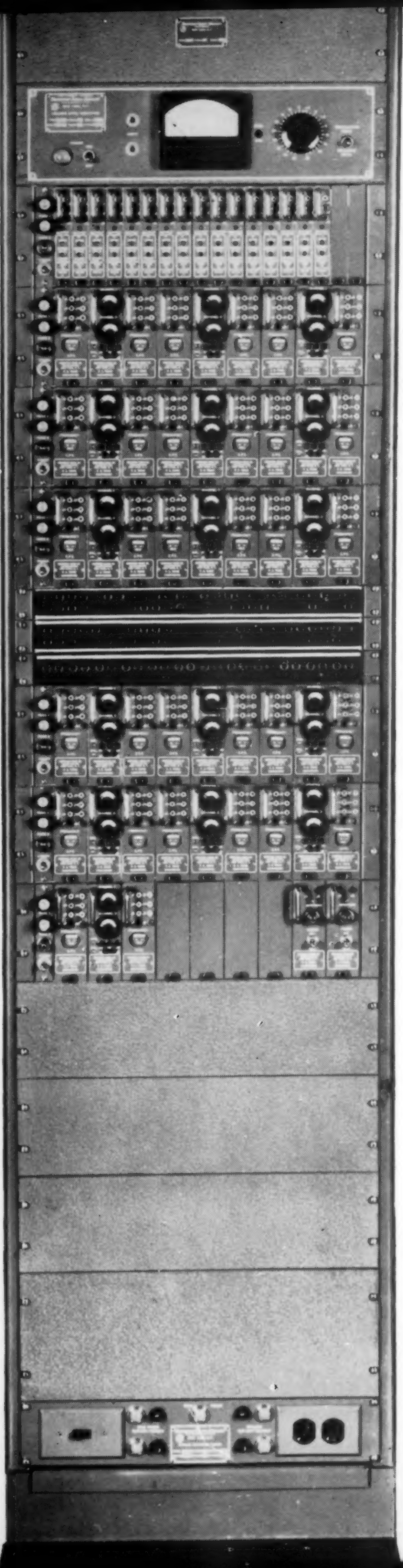
$$a_L = \sqrt{\frac{a_{22}}{a_{11}}\left(a_{11}\,a_{22} - \frac{b_t^2}{4a_{11}\,a_{22}} - a_t\right)} = \sqrt{M^2} \quad ..(21e)$$

and the power gain, under these conditions, is

$$G_s = \frac{(Y_{21})^2}{a_{11}} \cdot \frac{1}{2M + A} \quad \ldots\ldots(21f)$$

An alternative attack on the problem of determining the conditions which will allow maximum power gain is obtained by stipulating that the input admittance of the quadripole shall be the complex conjugate of a generator output admittance and that the output admittance of the quadripole with this generator

(Continued on page 41)



Miniaturized carrier system uses transistors

HAROLD PRICE, EDITOR*

Complete transistorization of the units which comprise a voice frequency carrier telegraph terminal has resulted in drastic size reductions. Functional and physical descriptions are given of the redesigned frequency shift tone keyer, tone converter, diversity combiner, and line amplifier

Transmitters reduced to one-twelfth of their former size, and receivers reduced to one-sixth former size. These are the results of transistorization as demonstrated by Northern Radio's new voice-frequency carrier telegraph system.

This multi-channel frequency shift system is designed for the transmission and reception of telegraph, teleprinter or telemetering signals over channels subject to fading or attenuation changes, such as point-to-point radio circuits.

Standard terminal equipment provides for the transmission of sixteen intelligence channels over one voice-frequency circuit, and diversity reception of 16 similar channels over two voice-frequency circuits. The two receiving circuits are normally obtained from radio receivers arranged for space diversity, but means are also provided for the use of frequency, rather than space, diversity. If necessary, a combination of space and frequency diversity may be used for maximum reliability.

The equipment for transmission and reception of 16 channels, including the necessary power supplies, jack fields and terminal strips, can be mounted in about two-thirds of a standard 7-foot telegraph rack.

DC current keying is used to control the type 211 frequency shift tone keyers. Received voice-frequency channels are normally passed through two line amplifiers type 236 to the inputs of the type 212 frequency shift tone converters. Appropriate telegraph channel filters in the converters select out the proper tone signal for demodulation by each converter. Pairs of converters receiving the same intelligence over different telegraph channels are connected together by means of type 234 diversity combiners. The stronger of the two signals controls the telegraph channel output device (either a transistorized or electro-mechanical relay), which is supplied as a plug-in unit in one of the converters.

The combination of the diversity combiners and tone converters produces a diversity receiving system that follows well-proven concepts, but which is claimed to out-

*Based on information provided by Northern Radio Manufacturing Company, Limited, Ottawa.

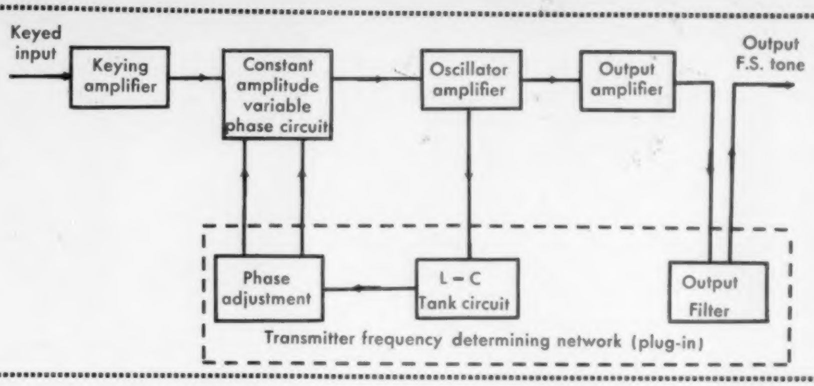


Fig. 1—Block diagram of the frequency shift tone keyer type 211

perform previously available systems. The diversity combiner employs logarithmic compression circuitry in obtaining the control voltage output, so that useful switching control is obtained at signal input levels as low as —60 dbm. Switching sensitivity is approximately uniform on the basis of the relative db levels of the two signals over the entire operating range of —60 dbm to 0 dbm. The companion frequency shift tone converters are also claimed to function perfectly at any level within this range and handle large dynamic level changes without introducing error, due to special design of the limiting circuitry.

Tone keyer

The type 211 frequency shift tone keyer is used in multi-channel communications systems to provide the transmitting terminals for teleprinters or telemetering operation over microwave or metallic circuits. The intelligence pulses shift the audio tones, which are then suitably amplified and controlled for inclusion in the transmission facility.

Any number of channels may be provided and a wide selection of keying speeds may be used, limited only by the pass-band of the transmission system. Usually, for teleprinter or telegraph work, a channel separation of 170 cps and a maximum keying speed of 100 words per minute are provided, and the following description is confined to units of this type. However, the design is flexible, and changing of sub-assemblies permits the use of almost any combination of channel frequencies and bandwidths (and associated keying speeds), to suit special requirements.

The tone keyer is a completely transistorized unit contained in a ⅞ in. by 5¼ in. by 10½ in. housing. It will operate, by changing a network, on any of the standard tone channels. The oscillator frequency of each unit is shifted ±42.5 cps about the desired channel centre frequency. This frequency shift is accomplished in such a manner that no appreciable frequency transient occurs other than the smooth transition from one frequency to the other. Transient conditions that would create signal distortion can thus be eliminated at the transmitting terminal.

A high-grade inductor-capacitor combination is used to establish the centre-frequency. The shifts of frequency, from this centre frequency, are accomplished through the use of variable-phase, constant-amplitude feedback loops. The frequency determining network is provided with an output filter which permits paralleling of the outputs of a number of keyers.

The signal inputs to the keyer are not grounded to the frame, so that either terminal may be externally grounded, or both terminals may be left floating, as desired. This arrangement allows the operation of the unit from a variety of keying circuits, having positive or negative batteries, and with either side grounded or ungrounded.

The use of transistors throughout this unit results in a device that is more compact, more reliable and far more efficient than has previously been possible. Internal heat in the unit is negligible, so that any number of keyers may be mounted in close proximity to each other without fear of excessive temperature rise due to heat dissipation.

As shown in Figure 1, the input signal is applied to the keying amplifier, causing the keying stage to assume a conducting or non-conducting condition. The output of this stage controls the constant amplitude, variable phase circuit. The latter completes an oscillation loop that includes the oscillator amplifier and the L-C tank circuit.

If the keying input is such that the keying stage advances the phase of the variable phase circuit, then the frequency of the L-C network is shifted to a higher value to cancel the phase shift. Conversely, if the keying stage

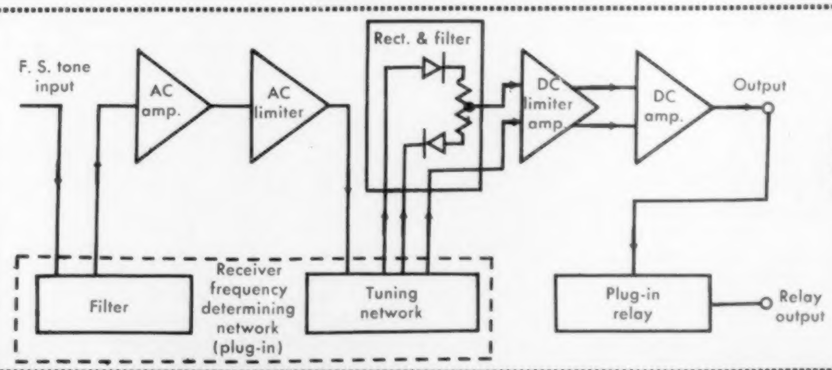
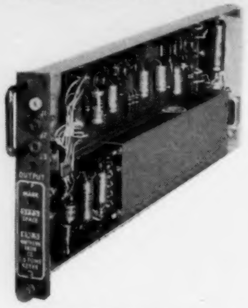
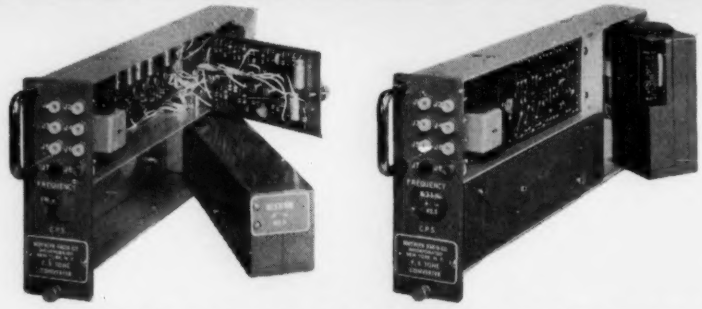


Fig. 2—Block diagram of the frequency shift tone converter type 212



Frequency shift tone keyer



Frequency shift tone converter; sub-assemblies swing open for easy access

retards the phase of the variable phase circuit, the frequency of the L-C network is shifted to a lower value. The separation between these two frequencies is determined by adjustments provided in the frequency-determining plug-in network unit.

The frequency shift tone from the oscillator amplifier is applied to the output amplifier stage, and then through the output filter to a 600 ohm unbalanced line.

Input impedance of the keyer ranges from 67 to 220 ohms. Frequency stability of the standard networks is ± 2 cps total, including $\pm 10\%$ line voltage variations and temperature changes from 0 to $+50$ deg C. All harmonics of the tone are more than 50 db below the output level of $+5$ db maximum, and the latter is not affected by $\pm 10\%$ line voltage variation.

Tip jacks are provided for making voltage tests and oscilloscope connections to the input and output circuit points. Controls available from the front of the panel include "mark" frequency, "space" frequency, and output level. Power requirements are only 15 ma at 14 vdc, and the unit weight is 3 lb, including the frequency-determining network. Eighteen units can be accommodated across a standard 19 in. rack, occupying a height of only 5¼ in.

Tone converter

The type 212 frequency shift tone converter provides the receiving terminal for the teleprinter or telemetering signals. Any number of channels may be provided and a wide selection of keying speeds may be used, limited only by the pass-band of the transmission system.

The frequency shifted tones that contain the intelligence pulses are received over the transmission facilities and converted electronically into dc voltage pulses that are suitable for directly driving printers equipped with internal repeating relays. Sockets are provided for plugging-in either electro-mechanical or electronic relays as required.

The flexible design of this unit allows it to be used as a link in telegraph systems that include signal improvement means such as signal regeneration and/or diversity reception. Supplemental equipment for these systems may be connected to the converter.

Like the keyer, the converter is completely transistorized. It is contained in a 1⅞ in. by 5¼ in. by 11¾ in. housing and will operate, by changing a plug-in unit, on any of the standard tone channels. The input of each unit consists of limiting amplifiers, followed by a frequency-discriminating circuit to demodulate the frequency shifted tones. This demodulated signal drives a dc amplifier, which provides the output voltage to the load circuit.

The use of simple balanced limiting circuitary following demodulation makes it possible to achieve a discriminator frequency-output characteristic closely approximating an ideal step-function. Thus, by reducing the "mark" to "space" transistion to a few cycles off centre frequency, signal distortion due to noise or bandwidth restriction is greatly minimized.

Balanced limiting amplifier circuits followed by diode limiters make it possible for this converter to handle very large instantaneous signal level variations without introducing errors.

Referring to Figure 2, the incoming tone is first passed through an appropriate band-pass filter to remove noise, interference and any other undesired signals, and into a limiter amplifier. The output of this amplifier is a push-pull square wave signal, which is fed into a two-coil discriminator for demodulation. The signal from each coil is full-wave rectified (to minimize signal distortion), and the outputs of the two rectifiers are differentially combined.

The resultant signal is applied to a balanced dc amplifier circuit, which requires only a small fraction of the available signal to produce full output. This arrangement has the effect of "slicing" a small portion from the centre of the discriminator signal, thus producing full "mark" or "space" output condition from a small part of the frequency deviation of the incoming signal. The dc amplifier serves as a proper impedance and voltage coupler between the dc limiter and the external load.

It should be noted that the input filter and the tuning network of the phase shifter amplifier are mounted together on a sub-assembly that plugs into the converter package. In this way, the basic converter unit may be used for any keying speed or tone frequency by selection of the proper receiving frequency-determining network.

The input impedance of the tone converter is 600 ohms, unbalanced, and input levels may vary from —60 dbm to $+8$ dbm. Input frequencies include all standard voice frequency channels from 255 to 3655 cps.

The output consists of neutral dc voltage pulses of 10 v maximum across a 2,000 ohms external load, or polar pulses of ± 10 v across a 1,000 ohms external load. The output drives appropriate voltage - to - current converters, such, as the Northern Radio type 213 transistor relay which is designed to provide proper teleprinter operating currents. Printers that are already equipped with internal repeating relays may be driven directly from the normal voltage output terminals of the converter.

Tip jacks are provided for testing, as with the keyer. Power requirements are 30 ma at 14 vdc; weight is 3 lb; and nine units can be mounted across a standard rack in a height of 5¼ in.

Diversity combiner

The type 234 diversity combiner is also completely transistorized and has over-all dimensions of 1⅞ in. by 5¼ in. by 11¾ in. It continuously compares the levels of the signals applied to its two input terminals and produces two output control voltages whose amplitudes are

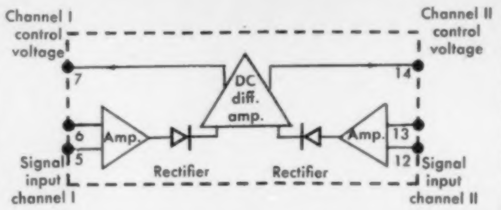


Fig. 3—Block diagram of diversity combiner type 234 which provides control voltage effective over a 60 db range of input signal level variation

determined by the relative amplitudes of the incoming signals (see figure 3).

The basic method of operation of this diversity system is conventional and well-known. The actual combining of the two signals is done at the output of the discriminator demodulators, which are connected in parallel. The signal that is instantaneously stronger is passed by diode selection to the common low-pass filter terminating circuit.

This method of selection has no time constants of its own and is therefore instantaneous; also, it functions at all signal levels. However, it is not completely satisfactory, since fairly large differences in signal amplitude are necessary to effect complete suppression of the weaker signal. The function of the diversity combiner is to accentuate the difference in the discriminator outputs and thus complete the desired suppression of the weaker signal. This is done by either increasing or decreasing the supply voltage available to operate the push-pull limiters that drive the two discriminators.

Novel means are used to obtain effective diversity action over a wide dynamic operating range. Signal amplification is combined with semi-logarithmic compression to provide a control voltage effective over a 60 db range of input signal level variation. Furthermore, the control voltage variation is approximately the same for a given db difference in the signal levels, without regard to their actual strengths. The end result is that the diversity action is as good at low signal levels, where it is needed, as it normally is at high levels.

The combiner is designed for modulation frequencies from 300 cps to 10 kc, and a normal keying speed of 50 dot cycles per second. Power requirement is 30 ma at 14 vdc. Unit weight is only 1½ lb, and nine units can be mounted across 5¼ in. of a standard rack.

Line amplifier

The type 236 line amplifier used in this system is a transistorized two-stage push-pull Class A amplifier with a transmission gain of 40 vu. It can also be used for studio or program amplification to boost the output of microphone, preamplifier or teletype tone signals to a level suitable for telephone lines or radio transmitter input. It is also suitable for use as a low level monitoring amplifier.

Two models are available, one with a self-contained power supply that operates from 110/220 v, 50/60 cps; the other model requires 0.15 watts at 14 vdc. Dimensions are the same as for the diversity combiner, and the unit weight is about one pound.

The input and output impedances can each be either 150 ohms single-ended or 600 ohms balanced; the change is effected by straps on the input and output transformers. Frequency response is ±1 vu over the designed frequency range of 300 cps to 10 kc, with noise 80 vu below the rated output level of +8 vu. END

4-terminal network—continued

shall be the complex conjugate of the load admittance' that is if

$$Y_g = a_g + jb_g \quad \text{and} \quad Y_L = a_L + jb_L$$

$$Y_{in} = a_{in} + jb_{in} = a_g - jb_g \quad \ldots\ldots\ldots\ldots (21g)$$

$$Y_{out} = a_{out} + jb_{out} = a_L - jb_L \quad \ldots\ldots\ldots (21h)$$

Solving these equations simultaneously for a_g, b_g, a_L and b_L yields various relationships

$$\frac{a_{11}}{a_{22}} = \frac{a_g}{a_L} = \frac{b_{11} + b_g}{b_{22} + b_L} \quad \ldots\ldots\ldots\ldots (21i)$$

$$b_g = \frac{b_t}{2a_{22}} - b_{11}, \qquad b_L = \frac{b_t}{2a_{11}} - b_{22} \quad \ldots (21j)$$

$$a_g = \sqrt{\frac{a_{11}}{a_{22}}\left(a_{11}\,a_{22} - a_t - \frac{b_t^2}{4a_{11}\,a_{22}}\right)},$$

$$\ldots (21k)$$

$$a_L = \sqrt{\frac{a_{22}}{a_{11}}\left(a_{11}\,a_{22} - a_t - \frac{b_t^2}{4a_{11}\,a_{22}}\right)},$$

The condition that real values of a_g and a_L shall exist is that M^2 shall be positive or that

$$(2a_{11}\,a_{22})^2 \;\geq\; 2a_t\,(2a_{11}\,a_{22}) + b_t^2 \quad \ldots (21m)$$

Returning to (21a), it may be shown that the locus of constant power gain in the a_L, b_L plane is a circle whose centre co-ordinates are

$$a_L = \frac{1}{2}\left[\frac{a_t}{a_{11}} + \frac{(Y_{21})^2}{a_{11}G}\right] - a_{22} \quad \ldots\ldots (21n)$$

$$b_L = \frac{b_t}{2a_{11}} - b_{22} \quad \ldots\ldots\ldots\ldots\ldots\ldots (21p)$$

and whose radius squared is

$$R^2 = \frac{(Y_{21})^2}{4a_{11}^2}\left[(Y_{12})^2 + \frac{1}{G^2}\,(Y_{21})^2 + \frac{2}{G}\,(a_t - 2a_{11}\,a_{22})\right]$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots (21q)$$

Setting a_L to zero in (21b), each constant power gain circle intersects the b_L axis at two points

$$b_L = \frac{b_t}{2a_{11}} - b_{22} \pm \sqrt{\frac{a_{22}}{a_{11}}\left(a_t + \frac{b_t^2}{4a_{11}\,a_{22}} - a_{11}\,a_{22}\right)}$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots (21r)$$

which may be written

$$b_L = \frac{b_t}{2a_{11}} - b_{22} \pm \sqrt{-M^2} \quad \ldots\ldots\ldots\ldots\ldots (21s)$$

The zero input conductance circle intersects the b_L axis at the same two points and its centre lies on the line (21p). This circle, then, is a member of the family of constant power gain circles. If the points of intersection of the zero input conductance circle with the b_L axis are real it follows that $(-M^2)$ is positive and M^2 is negative, the condition (21m) is not satisfied, conjugate matching of the quadripole is impossible and there is no real value of load conductance which will give a real maximum on the gain surface.

Constant power gain circles for 2N123 are shown in Figures 9 and 10. In Figure 9 the Zero Input Conductance circle intersects the susceptance axis; in Figure 10 it does not and there is, in consequence, a true power gain maximum. END

Acknowledgement

The author wishes to acknowledge the assistance given by Mr. P. G. Rioux in reviewing the mathematical content of this article.

Interplanetary travel will soon be undertaken by man

Rocket to the Moon

Erik Bergaust and Seabrook Hull; D. Van Nostrand Co. (Canada) Ltd., Toronto; 270 pp; $7

Trying to write a book on space travel is quite a risky thing these days. Scientists are closing the gap between fiction and fact so quickly that a book can become obsolete while it is still on the press.

The problem appears to have plagued the authors. Some sections of the book suffer from rather hasty preparation. With more time the writers could have achieved a much better presentation.

Despite this, the book is well worth reading. It provides a good introduction into the subject and discusses many of the small details that tend to be overlooked by most people thinking about space travel. Very little is said about the vehicles since the subject would be too difficult to explain in terms of the space available in the book, and the knowledge of the intended readers. Instead, the authors have discussed the human element. How does a man react to the extreme accelerations at blast-off? What will he eat? How will he react when outside the earth's gravitational field? These, and many other problems have been raised and answered by the authors.

Perhaps the most interesting part of the book is the criticism of the way in which the United States Government has mishandled the entire research program on space travel. This has cost them great loss of prestige among the nations of the world, and loss of faith from their own scientists. They must now work at top speed to catch up to the Russians, and the authors have detailed the U. S. programs in progress.

Nuclear Engineering Monographs

Temple Press Ltd., Bowling Green Land, London E.C.1

This series of six monographs on nuclear engineering subjects is intended for university and technical college students, research assistants and qualified technicians who require a broad understanding of those topics of nuclear engineering outside their own field of study. The publishers have aimed at meeting the requirement of low cost, and, at the same time, providing a broad treatment ranging from elementary principles to up-to-date summaries of more advanced theories.

Three of the monographs were received by CEE for review.

I. Elementary Nuclear Physics, by W. K. Mansfield; 10s. 6d. net

This is a good basic discussion of nuclear physics with emphasis on neutron physics and the interaction of nuclear radiation with matter. Equations are used to explain certain principles, but the mathematics is kept to a minimum and will be familiar to any reader with senior matriculation. The author has managed to inject a surprising amount of information into the 60-page book. Chapter headings are: The atomic theory of matter; The nucleus; Radioactivity; Neutron physics; Interaction of nuclear radiation with matter; Detection of nuclear radiation.

II. Nuclear Reactor Theory, by J. J. Syrett; 12s. 6d. net

This is an outline of the physics of reactor design. It provides a general description of the fission chain reaction and the conditions that must be met for the sustained operation of a reactor. Particular emphasis is given to the heterogeneous graphite-natural uranium thermal reactor. This is the type used in the first nuclear power stations in the U. K.

Chapter headings are: Nuclear chain reactions; Diffusion of thermal neutrons; Slowing down of neutrons; The calculation of critical size; Lattice calculations; Reactor operation at power; Types of reactor and fuel cycles; Appendix; Bibliography.

III. Reac'or Heat Transfer, by W. B. Hall; 10s. 6d. net

This monograph is more technical than the previous two. It has been written primarily for engineers and scientists engaged in nuclear work. The first chapter deals with the aspects of convective heat transfer which are of the greatest importance in reactor cooling. Chapter two describes the application of the basic heat transfer information to reactor design, and chapter three deals with a number of miscellaneous aspects of reactor heat transfer.

Three other monographs in the series, but not received for review, are: IV. Nuclear reactor shielding, by J. R. Harrison. V. Nuclear reactor control and instrumentation, by J. H. Bowen and E. F. O. Masters. VI. Steam cycles for nuclear power plant, by W. R. Wootton.

Burgess engineering manual

Burgess Battery Co., Dept. PR-1, Niagara Falls, Ont.; 97 pp; $1.

This manual has been published to provide industrial designers and research specialists with an engineering reference guide to help them choose the battery best suited to their design requirements. Types of dry cells described in the manual include familiar cylindrical cells, rectangular-shaped cells, new wafer cells and others.

Practical data provided on each type of battery includes: ASA reference letters and numbers; the number and size of cells used; weight; maximum physical dimensions; service life graphs; voltage taps and types of terminals used. Sketches of 69 different kinds of terminals are included in a separate section of the book.

How to design and specify printed circuits

Institute of Printed Circuits, 27 East Monroe St., Chicago 3, Ill.; $5 (U. S. A.)

This book is a group effort, representing experiences and skills of many manufacturers of printed circuits. It presents a general technical explanation of the sequence in adapting electrical and electronic wiring circuits to a single or coplanor printed wiring connecting structure.

The book also contains information on selection of materials and components, reliability, terminology and definitions, production methods, process limitations and soldering techniques.

Video Amplifiers (Electronic Technology Series)

Alexander A. Schure, Ph.D., Ed.D.; (John F. Rider Publisher, Inc.); Charles W. Pointon Ltd., Toronto; 88 pp; $1.90

This book provides an understanding of the problems encountered in the design and applications of video amplifiers. It utilizes examples that are easily applied to allied fields such as radar, television, and pulse amplification, where many video amplifiers are used.

It covers pulse waveforms used in the standard television signal; harmonic contents of the square wave and the sawtooth wave as determined by Fourier's equations; the gain and phase characteristics of an uncompensated amplifier are obtained at the low-, mid-, and high-frequency parts of the frequency range. Compensation circuits at high and low frequencies and their effects on the amplifier characteristics are fully illustrated.

Catalogues and brochures

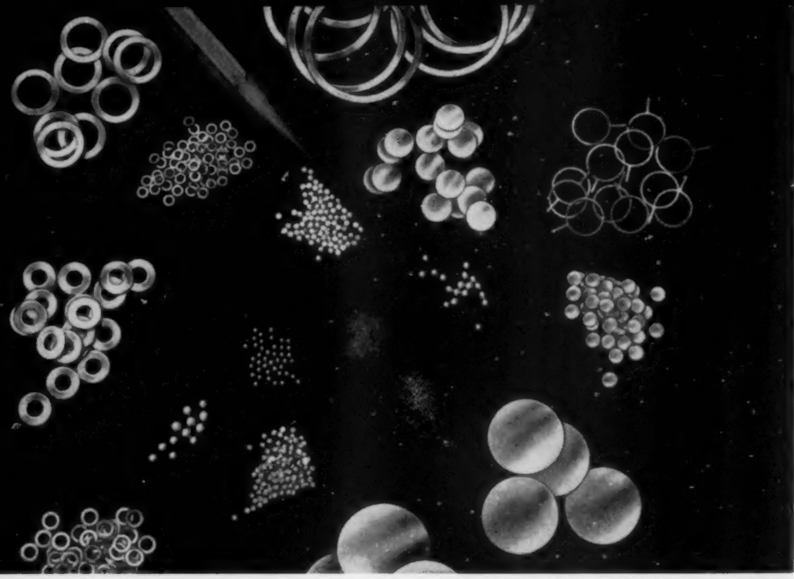
Switches and actuators. Bound reference catalogue ES-59 includes terminology definition, photos, specs, dimensional drawings and modification data on Electrosnap Corp. products. J. R. Longstaffe Co. Ltd., Toronto. (129)

Package assembly design. PIC Design Corp. booklet outlines "A to Z" engineering concept in the design of servomechanism gear train packages; 20 pages. Tecneek Associates, Montreal. (130)

Electronic counters. Northeastern Engineering technical data catalogue. Computing Devices of Canada, Ottawa. (131)

Electronic measuring instruments. 14-page catalogue lists Wandel u. Goltermann oscillators, signal generators, meters and other instruments. R-O-R Associates Ltd., Don Mills, Ont. (132)

For more information on New Product and Catalogue items, use Reader Service Cards on pages 55 and 56



133

Each of these items has a key number in the headline. For more information on any product, circle the corresponding number on the Reader Service card, add your name and address, then mail the card to CEE.

New products

Semiconductor preforms 133

High purity precision preforms, including discs, spheres, washers, and pellets used in making alloy junctions in silicon and germanium semiconductor devices are now available in a wide variety of alloys. The alloys include lead-antimony, indium-lead, gold-gallium, aluminum-gallium, and tin-antimony. Discs are held as close as ±0.0002 in. tolerance on diameters with flatness held within 0.0002 in. Spheres range from 0.001 in. diam. up to 0.125 in. diam. with tolerance held as close as ±0.0001 in. Washers are available in diameters from 0.025 in. od to 2.00 in. od with diameters guaranteed up to ±0.00025 in. and thicknesses to within ±0.002 in.

Accurate Specialties Co. Inc., Woodside, N.Y.

Epoxy molding powder 134

The first product in a new series, Hysol 8610, is a one-component powder offering long storage stability, low shrinkage on cure, improved electrical and mechanical properties at 150 C, and good dimensional stability. It is suitable for compression or transfer molding. It is recommended for coil and resistor bobbins, shells for electrical components, relay assemblies, connector plugs and switch gear.

Hysol (Canada) Ltd., Toronto.

Ultrasonic transducer 135

In the Acoustica multipower transducer, solid metal sections are used as integral operating elements and the active transducer material is positioned near the centre of the assembly. The metal elements are machined, dimensioned, and positioned so that the overall unit has amplitude of motion and heat dissipating capabilities. This minimizes the tendency to overheat at high power inputs, and provides a rugged construction. The manufacturer claims that the transducer can be hit by a hammer hard enough to dent the metal without affecting the operation of the unit.

Applications are for Sonar and ultrasonic cleaning.

X-Ray & Radium Industries Ltd., Toronto.

Silcad rechargeable battery 136

Silcad silver-cadmium rechargeable cells have been designed for use where high energy from minimum space is required, with a minimum of maintenance to give long life. Manufactured in Canada, the cells may be packaged into a variety of sizes, depending on the specific application.

Silvercel of Canada Ltd., Toronto.

Two audio amplifiers 137

Two new high fidelity amplifier kits have been introduced by Eico. They are the HF14 14-watt amplifier and the HF35 35-watt ultra-linear amplifier.

The HF14 has a Williamson type circuit with push-pull EL84 output stage. Rated output power is 14 watts continuous or 28 watts peak. IM distortion (60 cps and 7 kc at 4:1); 1.7% at 14 watts, 0.33% at 6 watts, 0.1% at 4 watts. Harmonic distortion is less than 1% from 30 to 10 kc (at 8 watts); less than 1% from 40 to 10 kc (at 10 watts); less than 1% from 50 to 5 kc (at 14 watts).

Model HF35 employs a low noise EF86 pentode voltage amplifier direct-coupled to a 6SN7GTB cathode-coupled phase inverter, driving a push-pull EL34 tapped-screen output stage. Rated output power is 35 watts continuous, 70 watts peak. IM distortion (60 cps and 7 kc at 4:1) is 1.5% at 35 w; 0.15% at 20 w. Harmonic distortion is below 1% at any frequency from 20 cps to 20 kc within 1 db off 35 w.

Ron Merritt Co., Vancouver, and John R. Tilton Ltd., Toronto.

Power supply unit 138

A new power supply combining the characteristics of magnetic with the response of transistor regulators, the Magitran can be short-circuited intermittently or continuously without damage, and has no fuses or breakers to reset.

The voltage is continuously variable from 0-36 v, with current ranges to 20 a. Vernier voltage, panel metering, remote sensing and close line and load regulation are among other features of this new unit.

Hoover Co. Ltd., Electronic Component & Equipment Dept., Hamilton.

Altitude chamber 139

To facilitate the testing of heavy units or components, this American Research Corporation self-contained altitude chamber has a low-loading level. The bottom of the 64 cubic foot test space is only 29 in. from the floor. The chamber provides temperatures from —100 F to +300 F, altitudes to 150,000 ft, and relative humidity from 20 to 90%. The chamber is delivered completely pretested with all necessary instrumentation for completely automatic operation and recording.

Computing Devices of Canada Ltd., Ottawa.

Differential pressure transmitter 140

A zero setting differential pressure transmitter, model 70-2900 features 0.2% measurement accuracy, infinite resolution and zero output pre-set at any point throughout the range. The shock resistant differential pressure transmitter is suitable for corrosive atmospheres and is available in standard pressure ranges of from 0-100 to 0-3,000 psi with differentials up to 100% of range. Inputs available are 6.3 vac or 110 vac, and full scale outputs available are 50 mvdc, 5 vac, or 5 vdc. The sensing element of the unit is a differential transformer with a built-in demodulator for dc outputs.

International Resistance Co. Ltd., Toronto.

Vibration isolators 141

The Lo-Rez standard vibration isolators have static deflections as high as 10 inches, permitting the efficient control of disturbing frequencies as low as 125 cpm. Special isolators will provide even higher deflections. These isolators can reduce vibration to negligible levels when properly installed as supports on equipment.

Vibron Ltd., Toronto.

Heavy-duty enclosures 142

Built to N.E.M.A. and J.I.C. standards, this new line of single and double door panel boxes and enclosures is designed around the "most wanted" dimensions in a complete range of sizes. Standard models are equipped with removable interior panels. Floor mounting feet and dry ledge are available as separate items.

Hammond Manufacturing Co. Ltd., Guelph, Ont.

Lightweight aircraft connector 143

The type DPSM connector utilizes a magnesium shell to reduce weight to a minimum. The connector is fully environmental resistant and will operate under high vibration conditions, through a temperature range of —65 F to +300 F. To maintain electrical characteristics at high altitude, the connector has a special sliding seal of resiliant Silcan 63 material, lubricated for ease of separation. This permits a 1/8 in. axial tolerance while still effecting a seal.

Cannon Electric Canada Ltd., Toronto.

Distributed port speaker enclosure 144

The Stereo Classic EN-50 is a five-cubic-foot distributed port enclosure for use with 12-inch speakers. It has an optional front panel tweeter mount opening with a removable cover plate for tweeters of four inches outside diameter or less.

The seven distributed port openings are in the rear panel to eliminate grille cloth interference and improve the enclosure's accoustic resistance. The enclosure is designed to accommodate air pressures of speakers of 60 watts.

Canadian General Electric Co. Ltd., Toronto.

Low voltage capacitors 145

Designed for printed circuitry applications where low voltage, high temperature and rugged construction are needed, these capacitors are available in the range from 0.0001 ufd to 0.25 ufd. They are metal encased, hermetically sealed with axial leads, and have been designed for continuous operation from —70 C to 175 C without derating. Working voltage is 15 dc (flash 30 vdc). They have been designed to meet the requirements of MIL C 25 A.

Douglas Randall (Canada) Ltd., Scarborough, Ont.

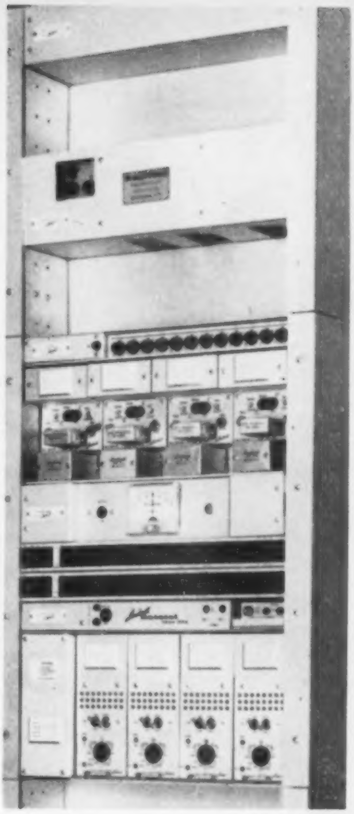
Telegraph and data carrier system 146

Lenkurt telegraph and data carrier system, type 23A Datatel can be operated end-to-end or back-to-back with Western Electric type 43A telegraph systems without use of auxiliary coupling units.

Available options include all standard loop arrangements. Where loop length is not excessive the loop may be operated from the 48-v central office battery. Bridging or branching arrangements are simplified by optional panels.

The equipment is fully transistorized and operates from either 48 or 130 vdc supply.

Automatic Electric Sales (Canada) Ltd., Toronto.



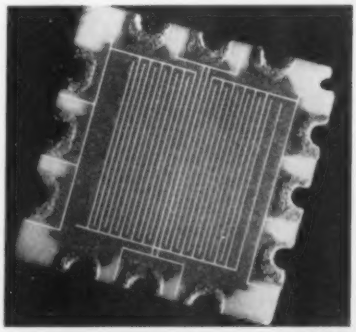
146

Molecular constructed resistors 147

These micro-miniature resistors are a solid state material in the form of a ceramic wafer approximately 10 thousandths of an inch thick and 0.35 in. square. By processing suitable substrates, these micro-wafers are inscribed with a series of isolation lines which produce the resistor characteristics desired. Single or double-sided resistor elements can be designed, and various combinations of circuitry can be employed with the basic micro-element.

Each resistor element, weighing 50 milligrams, contains four resistors averaging 10,000 elements (or 40,000 resistors) to the pound and a packing density of 600,000 parts per cubic foot. Basic module forms may be stacked or interconnected, using as many or few micro-elements as desired.

Daystrom Ltd., Toronto.



147

Teflon insulation stripper 148

Designed for use on wire sizes up to No. 20 AWG, this insulation stripper provides a means of removing Teflon insulation without breaking or nicking the wire strands. A replaceable heated wire loop is used to vaporize a small ring of insulation around the circumference of the wire, permitting easy removal of the desired length of insulation. The toxic nature of Teflon vapors requires the stripper to be used in a well-ventilated hood.

Western Electronic Products Co., Altadena, Calif.

148

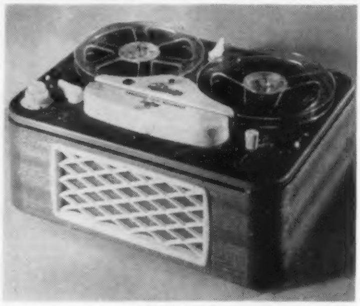
(Continued on page 46)

New products—cont.

Stereo tape recorder 149

The Tandberg 5 offers complete facilities for recording and playing stereo and monaural tape. It provides 4-track stereo and monaural recording and playback, plus playback of 2-track stereo, ½-track monaural tape and ¼-track monaural tape.

Tape speeds are 1⅞, 3¾, 7½ ips; frequency response (NARTB equalization) is 30 to 8,000 cps at 1⅞ ips. Flutter and wow is 0.1% at 7½ ips, 0.2% at 3¾ ips, 0.25% at 1⅞ ips.



The basic model 5 instrument will play back in monaural or stereo, but will record monaural only. With the addition of an auxiliary recording amplifier it will then record in stereo as well.

Engineered Sound Systems Ltd., Toronto.

Automatic pan tv mount 150

This heavy duty tv camera mount, produced by Kin Tel permits the continuous monitoring of a broad area by a single closed circuit tv system. The model ARC-11B camera mount circles from side to side in a continuous back-and-forth action, panning the tv camera over an adjustable sector. Built-in speed controls allow the scanning cycle to be varied over a wide range, from 0 to 12 deg per second. Tilting speed is adjustable from 0 to 4 deg per second. The

action may be stopped or started by panel switches; dynamic braking is provided for instantaneous stops with no overshooting.

Atlas Instrument Corp. Ltd., Toronto.

Pulse generator 151

The Rutherford model B3-2A is a high repetition rate multiple pulse generator. The unit consists of a repetition rate generator providing rates from 10 cps to 1 mc, four variable delay circuits with delay from 0 to 10,000 usec for controlling the pulse position or pulse width, and two pulse-forming units producing pulses of positive or negative polarity with rise and fall times of 0.02 usec and amplitude of 25 v. Output impedance is 50 ohms. Duty factor of the output pulse is 25%. The rise time can be degraded to 1 usec.

Electrodesign, Montreal.

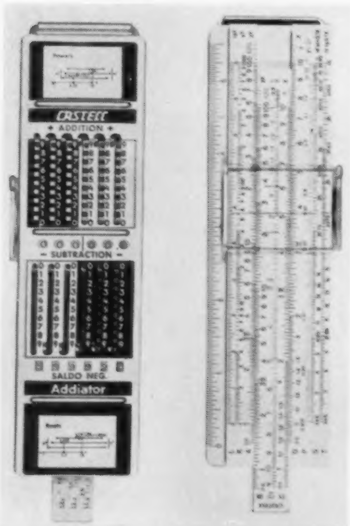
Ringing tone generator 152

The RG-1 ringing tone generator is a fully transistorized unit which operates directly from office or switchboard battery. The tone frequency is 20 cps ± 2 cps within specified ranges of temperature, supply voltages and load. Power output is 20 watts on continuous duty. This is adequate to operate 20 type B1A ringers simultaneously. Current drain under no load conditions is 0.20 amps (on 24 v supply) or 0.10 amp (on 48 v supply). Current drain at full load (20 w) is 1.10 amp (on 24 v supply) or 0.55 amp (on 48 v supply).

Pylon Electronic Development Co. Ltd., Montreal.

This slide rule can add 153

This pocket-sized calculator combines a Faber-Castell 13-scale log-log-slide rule on one side, and Addiator (an adding machine) on the other. The 5-in. scale includes K, A, B, CI, C, D, P, LL_1, LL_2, LL_3 scales. On the reverse side, the machine can provide addition or subtraction up to six digits.



There is a 10-in. model available.

Harrison Home Products Corp., New York, N.Y.

(Continued on page 50)

Defence contracts

Unclassified electronics contracts for $10,000 or more have been awarded to the following Canadian firms by the Department of Defence Production. A figure in parenthesis indicates the number of contracts, the amount being the total value.

February 16-31, 1959

Ampex American Corporation, Ottawa, tape recording system, $30,521.

Beaconing Optical and Precision Materials Co. Ltd., Montreal, test equipment, $137,211.

Campbell Manufacturing Co. Ltd., Willowdale, Ont., spares for radio equipment, $25,254.

Computing Devices of Canada Ltd., Ottawa, airborne mapping equipment, $46,444.

Dominion Steel & Coal Corp. Ltd., Trenton, N.S., construction of underwater airtight housing for equipment, $19,369.

Ertel of Canada Ltd., Montreal, fire control equipment, $22,651.

Micro - Tower Ltd., Scarborough, Ont., microwave tower and antenna supporting frame, $19,890.

Redifon Canada, Montreal, technical services during year ending March 31/60, $11,054.

Renfrew Electric Ltd., Renfrew, Ont., test equipment, $82,060.

R.O.R. Associates Ltd., Don Mills, Ont., equipment, $33,000.

March 1-15, 1959

Abercorn Aero Ltd., Montreal, radar equipment, $21,682; spares for marine safety equipment, $11,194.

E.M.I. - Cossor Electronics Ltd., Halifax, equipment, $11,124.

Instronics Ltd., Stittsville, Ont., equipment, $24,380.

R.C.A. Victor Co. Ltd., Ottawa, equipment, $12,604.

Safety Supply Co., Ottawa, spares for communications equipment, $14,006.

Sperry Gyroscope Ottawa Ltd., Ottawa, equipment, $12,462.

Canadian national business show

Sponsored by the Canadian Business Equipment Manufacturers' Association, the second Canadian National Business Show will be held June 8-10 in the Automotive Building, Exhibition Park, Toronto.

A 20% increase in exhibit space will be available this year, and early bookings indicate that electronic equipment will be featured in several displays.

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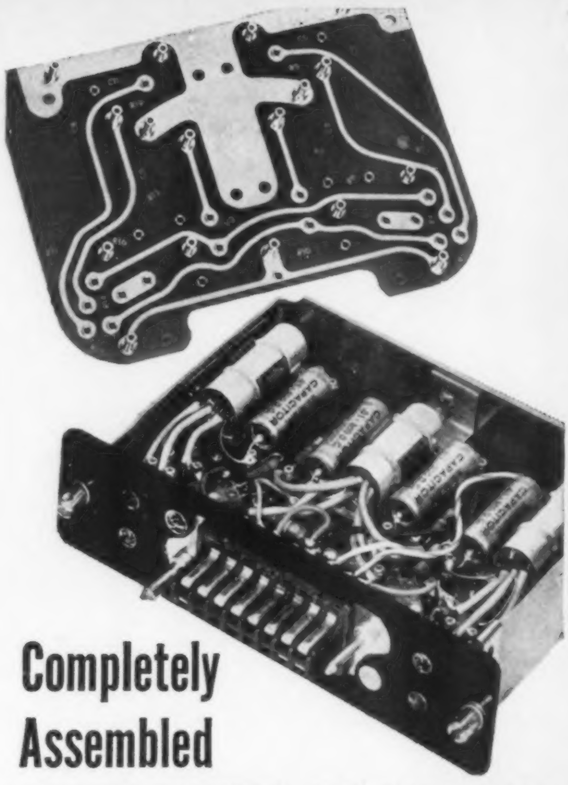

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New products — continued

Teletype pageprinter 154

The Siemens pageprinter model 100 has been designed for use with a number of auxiliary equipment to provide a versatile teletype system. It utilizes the international telegraph code No. 2 and has a standard telegraph speed of 66 words per minute (100 wpm optional). Input voltage is 220 v, 40-60 cps (other inputs available). The standard keyboard has four rows and the standard characters are 69 (pica) characters per line. 72 characters per line available on special order.

The Ahearn and Soper Co. Ltd., Ottawa.

Multipurpose generator 155

The Type 1391-B is a versatile laboratory instrument which generates push-pull pulses, linear sweep voltages, time delays, and delayed trigger pulses which can be used independently or to delay the initiation time of the sweep and main pulse relative to the input driving signal.

Signals of almost any wave shape will trigger the input timing circuits. Transition times of the output pulses (0.015 usec rise time) are compatible with most present-day oscilloscopes.

Pulse duration is 0.025 usec to 1.1 sec between half amplitude points, with repetition rates up to 300 kc. The time delay range is from 1.0 usec to 1.1 sec and has a maximum prf of 400 kc. Sweep duration range is 3 usec to 0.12 sec, and the maximum repetition rate for 3 usec sweep is 250 kc.

General Radio Co., Toronto.

Portable audio console 156

The R5460B audio console is an ac or battery operated single channel transistorized unit, designed for remote

broadcast operations. The power supply employs semi-conductors as rectifiers, and a fail-safe feature automatically switches to battery operation if the line power fails.

The unit contains four separate printed wiring preamplifiers, with high level mixing and balanced inputs. The amplifiers are in the form of a plug-in cards to facilitate servicing.

The console comes well within TR105B specifications for frequency response, and distortion with full rated output of +18 dbm (after line pad).

Northern Electric Co. Ltd., Montreal.

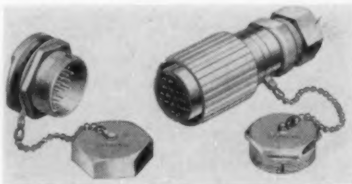
Oscillograph recorder amplifiers 157

Edin, a division of Epsco, Inc., has introduced the B series amplifier intended for a wide variety of both rack-panel and oscillograph recording needs. These amplifiers drift less than 0.5 mv equivalent input per hour, and will operate from 110-120 v power lines without additional regulation. Two megohms input impedance, plus optional zero suppression, allow this unit to be used in a wide variety of applications. A plug-in compensation network extends the range of standard Edin direct-writing galvanometers to 200 cps, and automatic signal overload protection avoids galvanometer burnout.

A. C. Wickman Ltd., Electronics Div., Toronto.

Submersion-proof connectors 158

The series 89 connectors have been designed for heavy duty use in outdoor applications of connecting electronic and communications equipment. An internal rubber gasket in the cable clamp, a type W washer, at the mating faces provides water-proof protection.



To facilitate handling in rough weather, coupling rings are extra long and heavily grooved. Flats are conveniently located for field servicing with standard open end wrenches. Caps and chains are provided for all connectors.

Amphenol Canada Ltd., Toronto.

Punching laminate 159

A laminated thermosetting plastic, Spauldite grade 802 combines clean punching with toughness. It is recommended where smooth machined or punched edges are required, and is being used for electronic parts where close tolerance is essential.

Spaulding Fibre of Canada Ltd., Toronto. END

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A 3½" meter has the scale length and readibility of a conventional 6" meter.

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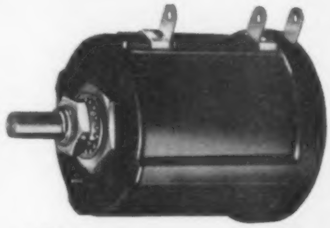
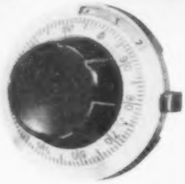
0.25% Linearity now standard in Model A Helipots

0.25% linearity and 3% resistance tolerances now **standard** in values between 100 ohms and 100K. Other resistances are 0.5% linearity and 5% tolerance.





STANDARD VALUES

25 ohms	5K ohms
50 "	10K "
100 "	20K "
200 "	30K "
500 "	50K "
1000 "	100K "
2000 "	200K "
	300K "

Prices FOB Toronto or Montreal

Model A Helipot $12.50
RB Duodial 7.20

sales tax extra

Substantial quantity discounts

Model A pots can be supplied with linearity to .05% and in any value between 10 ohms and 450K. Taps and ganged sections also available.

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Advertisers' Index

Key No. **Page No.**

A

10 Arnold Engineering 8
11 Automatic Electric Sales (Canada) Ltd. 18

B

12 Bach-Simpson Ltd. 16
13 Bomac Laboratories, Inc. .... IFC
14 Bud Radio, Inc. 53
15 Burndy Canada Ltd. 15

C

16-17 Canada Wire and Cable Co. Ltd. 9-10
18 Canadian Marconi Co. 14
19 Centralab Canada Ltd. 6
20 Conrad, Inc. 47

E

21 Eitel-McCullough, Inc. .... OBC

F

22 Federal Wire & Cable (Divisions, H. K. Porter Co. (Canada) Ltd.) 2

H

23 Hammond Mfg. Co. Ltd. 49
24 Heinemann Electric Co. 46
25 Hewlett-Packard Co. .... IBC

M

26 Muirhead Instruments Ltd. 48

N

27 Northern Radio Mfg. Co. Ltd. 12-13

O

28 Ohmite Mfg. Co. 52

P

29 Potter & Brumfield Canada Ltd. 4
30 Precision Electronic Components (1956) Ltd. . 52
31 Pylon Electronic Development Co. Ltd. 52

R

32 Railway & Power Engineering 43
33 Rogers Electronic Tubes & Components, A Division of Philips Electronics Industries Ltd. 17
34 R-O-R Associates Ltd. 51

S

35 Stark Electronic Instruments Ltd. 51

T

36 Texas Instruments Incorporated 50

U

37 United-Carr Fastener Co. of Canada Ltd. 49

Peter Munk, president and co-founder of Clairtone Sound Corp. Ltd., checks out a stereo radio-record player combination before shipment to U. S. buyer.

Round up: news and future events

New Canadian company invades the U.S. audio market

Running counter to the flow of United States electronic equipment that is being imported into Canada, a Toronto company has broken into the U. S. high fidelity and stereophonic market.

Clairtone Sound Corp. Ltd. has shipped some 200 sets to the United States since receiving its first order last March. The model 100 has set other records too. It won a first prize in the 1959 Design Awards of the National Industrial Design Council, Ottawa.

President and co-founder of Clairtone is Peter Munk, a graduate in electrical engineering, University of Toronto, 1952. Vice-president and co-founder is David H. Gilmour, a furniture designer and importer.

Rent electron microscope

Electron microscope facilities may be rented on a contract basis from the Ontario Research Foundation. The Foundation has recently acquired a Siemens electron microscope to implement certain fundamental research projects being conducted there. However, in accord with one of the objectives of the Foundation — to make available specialized equipment to all industry—ample opportunity will be made for industry to incorporate this facility into their research programs.

A meeting of the Ontario group of Electron Microscopists was held at the Ontario Research Foundation recently. The microscope was demonstrated and a talk given by Dr. C. Von Muschwitz. Guest speaker was Dr. Michael Watson of the University of Rochester who spoke on "Heavy metal staining of tissue sections for electron microscopy."

Computer course

The University of Ottawa is offering a 14-day course in scientific computation. Lectures will cover programming and operation of the IBM 650 digital computer, with practical work and elementary numerical analysis. The course starts May 11 in the Chemistry building, 365 Nicholas St., Ottawa.

Toronto IRE news

New officers of the Toronto Section of IRE have been elected. Chairman is R. J. A. Turner of Lake Engineering Co. Ltd.; vice-chairman is K. MacKenzie of McCurdy Radio Industries Ltd.; secretary-treasurer is G. T. Quigley of Philips Electronics Industries Ltd.

Forty one members of IRE in the Toronto area have expressed interest in forming a Toronto Chapter of the Professional Group on Communications Systems. The purpose of such a group would be to represent the interests of its members, stimulate and conduct activities in the field of interest of the group, and to co-ordinate these with the local activities of the Section and with the national activities of PGCS. Interested persons can obtain further information from F. Ford, LEnnox 4-6511, ext. 518.

COMING EVENTS

May

4-6	National Aeronautical and Navigational Electronics Conference, Dayton, Ohio.
4-8	National Industrial Production Show of Canada, Exhibition Park, Toronto.
6-8	1959 Electronic Components Conference, Philadelphia, Pa.
6-8	National Community Antenna Television Assoc. of Canada convention, Montreal.
7-8	Canadian Operational Research Society first annual conference, University of Toronto.
14-16	Acoustical Society of America convention, Chateau Laurier, Ottawa.
18-20	Electronic Parts Distributors Show, Chicago.
21-27	International Convention on Transistors, Savoy Place, London, W.C.2.

June

8-10	Canadian National Business Show, Exhibition Park, Toronto.
12-28	Electrama, general exhibition of the French Electrical Engineering Industries, including electronics, Paris.
13-22	International Conference on Information Processing, Palais d'Exhibition, Paris, France.
15-July 5	VI International congress and exhibition of electronics and atomic energy, Rome, Italy.

August

26-Sept. 5	26th National Radio and Television Exhibition, Earls Court, London.
31-Sept. 2	Metallurgical Society of AIME conference on properties of elemental and compound semiconductors, Boston.

Directory for Canadian buyers

The CEE Components and Equipment Directory is ready to celebrate its first birthday. After only one year it feels quite mature too. It has provided a valuable service to engineers and purchasing agents faced with the problem of "Where do I get it?"

There have been a few errors, and some recognized omissions, but these are being corrected for the 1959-60 edition of the directory to be published in June.

Free service for our readers

Keep your reference shelf up to date this easy way. All advertisements, new products and literature in this issue have a key number. For more information

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31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135
136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165
166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195

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16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135
136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165
166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195

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